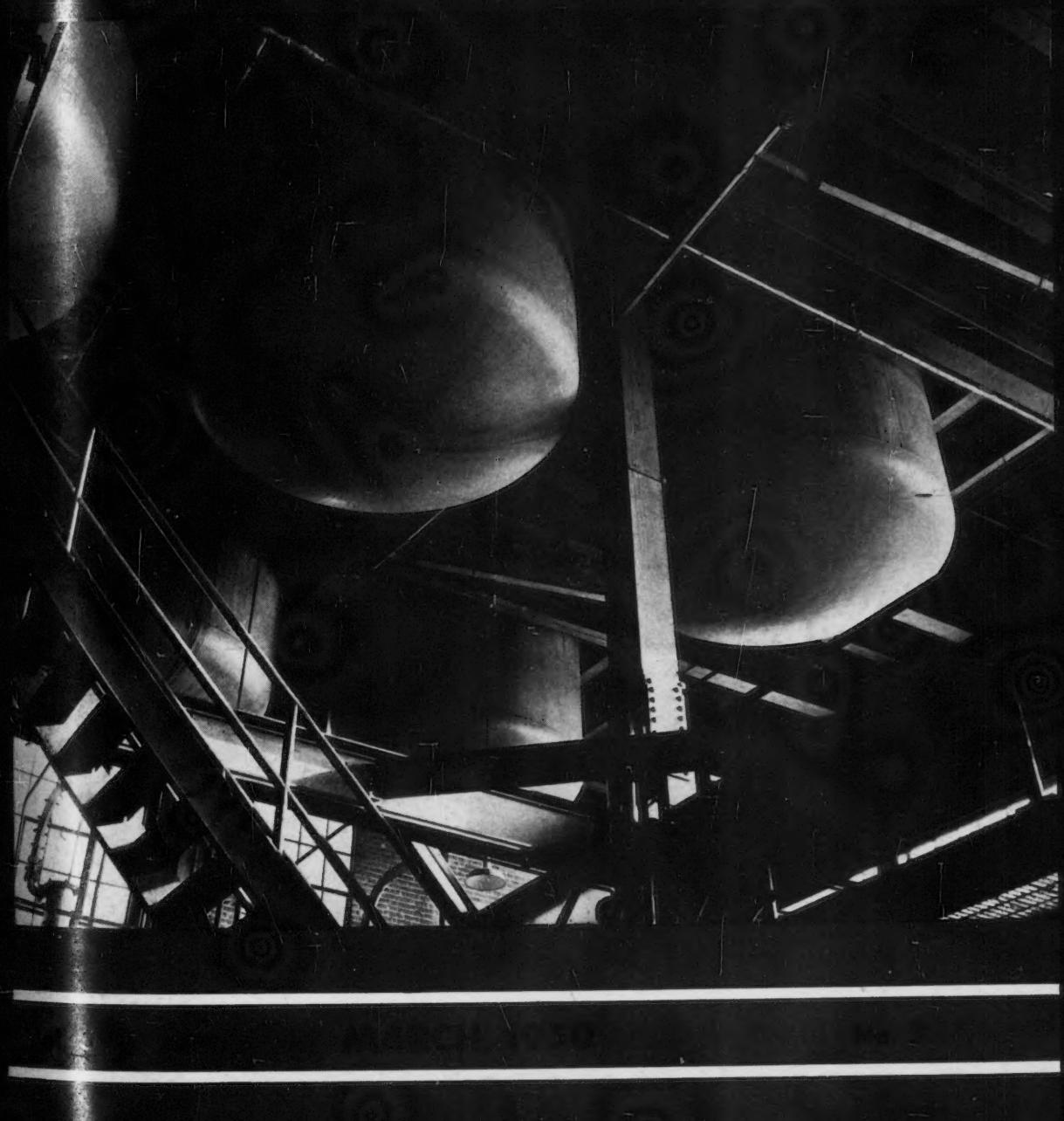


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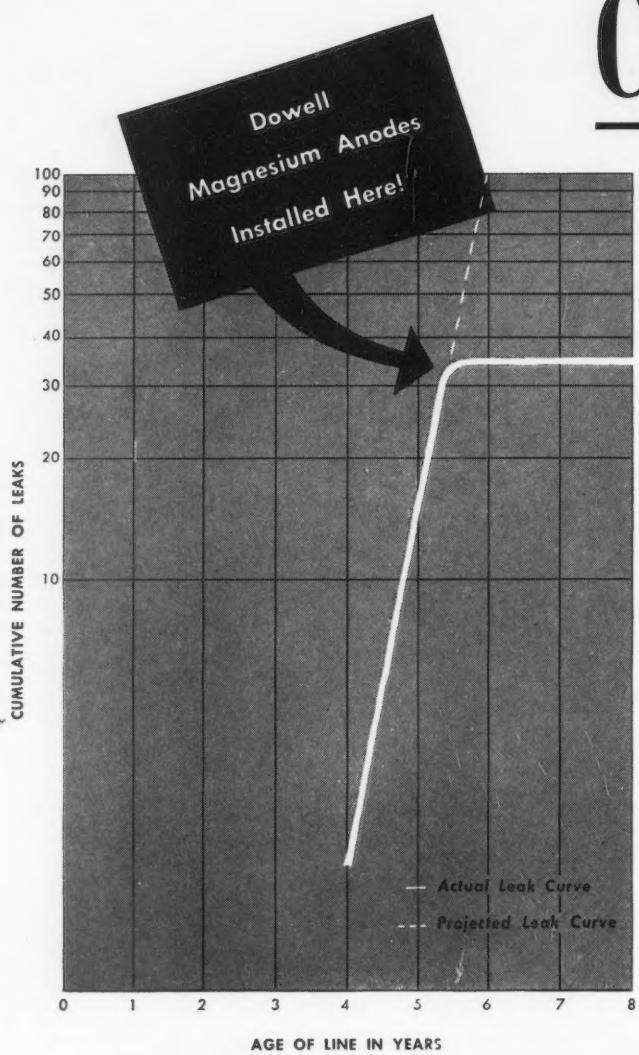
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were laid
Chemicals
brick.

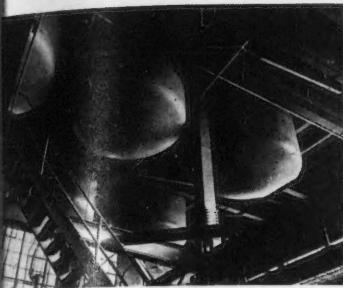
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devoted entirely to

CORROSION

Research and Control

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MARCH, 1950

NO. 3



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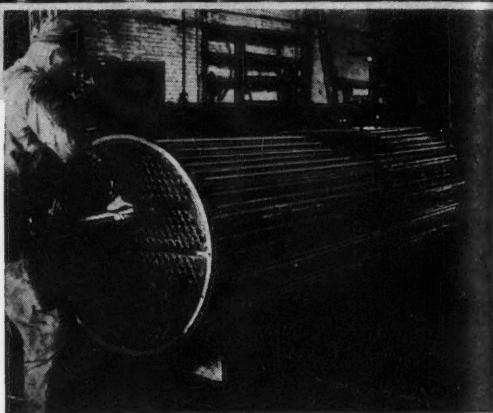
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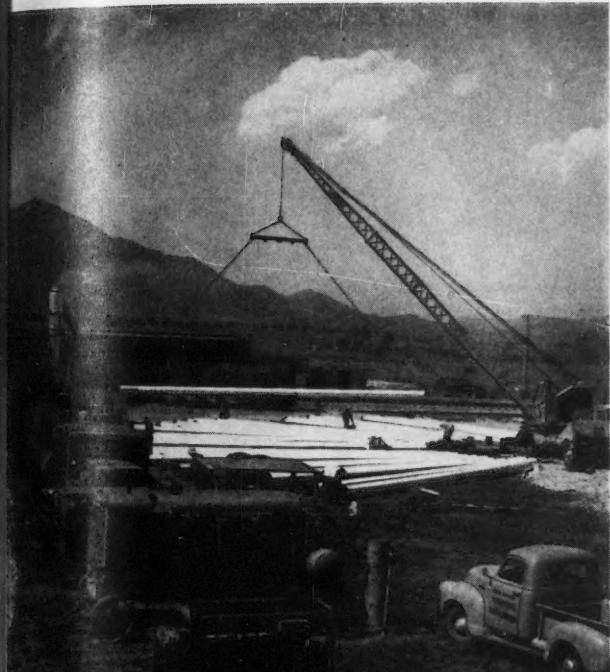
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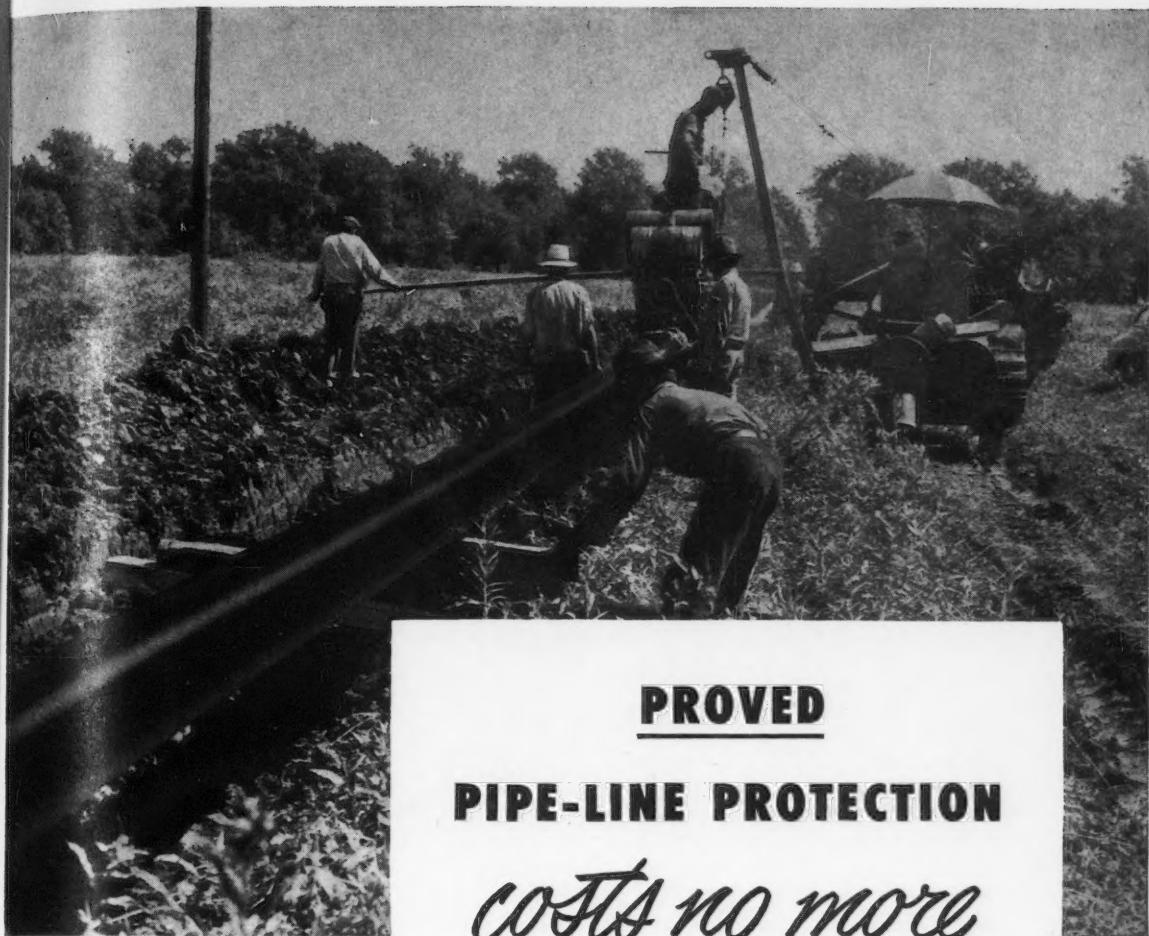
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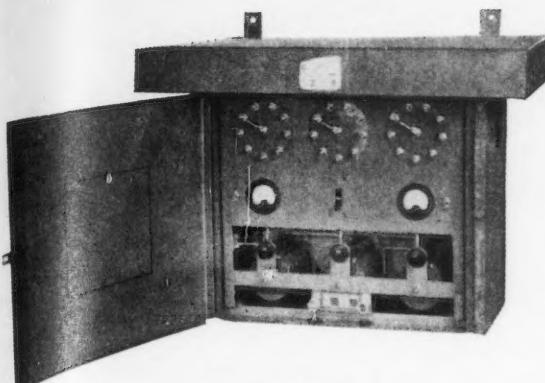
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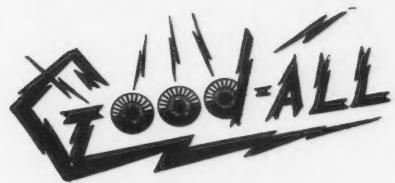
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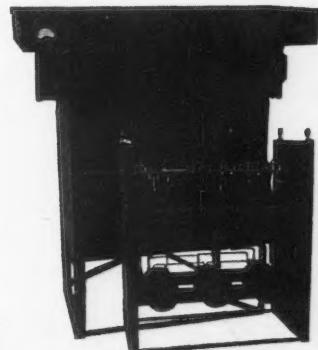
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Technical Committee Activities

Electrical Grounding Practices Affecting NACE Technical Practices Sub-Committee TP-12

By H. L. HAMILTON*

TP 12 Sub-Committee was formed to investigate a growing tendency towards grounding the positive polarity in direct current systems. The departure from negative polarity grounding was recommended as a result of a serious corrosion problem in large water-air cooled mercury arc rectifiers. This change from the commonly used negative polarity grounding corrected the difficulty in the specific equipment but neglected the corrosion effects in related plant and nearby structures. The final report of minutes and recommendations by this committee was published in the September 1949 issue of "Corrosion." While this endeavor was elementary in scope to experienced corrosion engineers, there was an excellent indication for the need of NACE technical activities. Of the 26 men on this committee 13 were not NACE members.

At the 1949 Annual Conference at a scheduled TP 12 meeting the "Types of Metals Used in Grounding Systems" was presented as the next subject for committee action.

Discussion of the proposed investigation has revealed that the American Institute of Electrical Engineers is conducting a parallel study of this

problem. Rather than duplicate their effort, the proper representative of the Inter-Society Correlating Committee has been contacted to outline a policy.

This proposed activity has aroused considerable interest and promises to be most interesting and useful in reducing the corrosion loss. In this endeavor the initial items for consideration will be (1) rectifying films on buried metals, (2) metal-metal potential differences as found in practice, (3) metallic coatings, (4) metals' conductivity, and (5) more satisfactory use of copper in grounding systems.

The intention of this committee is to establish sub-committees in (1) Power, (2) Communication, and (3) Transportation Industries. These activities are being withheld until a policy is established. In the interim experiences are being accumulated to assist in the proposed studies.

Many quarters are looking for reliable technical information on various corrosion problems. This is certainly an important function of NACE, success being measured by active and energetic membership participation.

Engineers with experience or interest in this subject, "Types of Metals Used in Grounding Systems," are urged to communicate with this committee chairman so that maximum information and coverage will result.

*Chairman, National Association of Corrosion Engineers Technical Practices Sub-Committee 12—Electrical Grounding Practices, Keystone Pipe Line Company, Philadelphia, Pa.

THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS

is a non-profit, scientific and research association of individuals and companies concerned with corrosion or interested in it, whose objects are:

- (a) to promote scientific research in determining the causes of corrosion and methods of its control with respect to theory and practice.
- (b) to provide a means of exchange of knowledge and ideas among those individuals actively engaged in the control of corrosion.
- (c) to promote methods of control of corrosion.
- (d) to promote standardization of terminology, methods, equipment and design in the development of methods of corrosion control.
- (e) to foster cooperation between individual owners of metallic structures in the solution of their joint corrosion problems.

It is an incorporated association without capital stock, chartered under the laws of Texas. Its affairs are governed by a Board of Directors, elected by the general membership. Officers are nominated by (1) the Board of Directors, or (2) a quorum of at least 25 members, and elected by the membership.

Inquiries regarding membership, and all general correspondence should be directed to the Executive Secretary at the administrative headquarters of the National Association of Corrosion Engineers at 919 Milam Building, 803 Texas Avenue, Houston 2, Texas.



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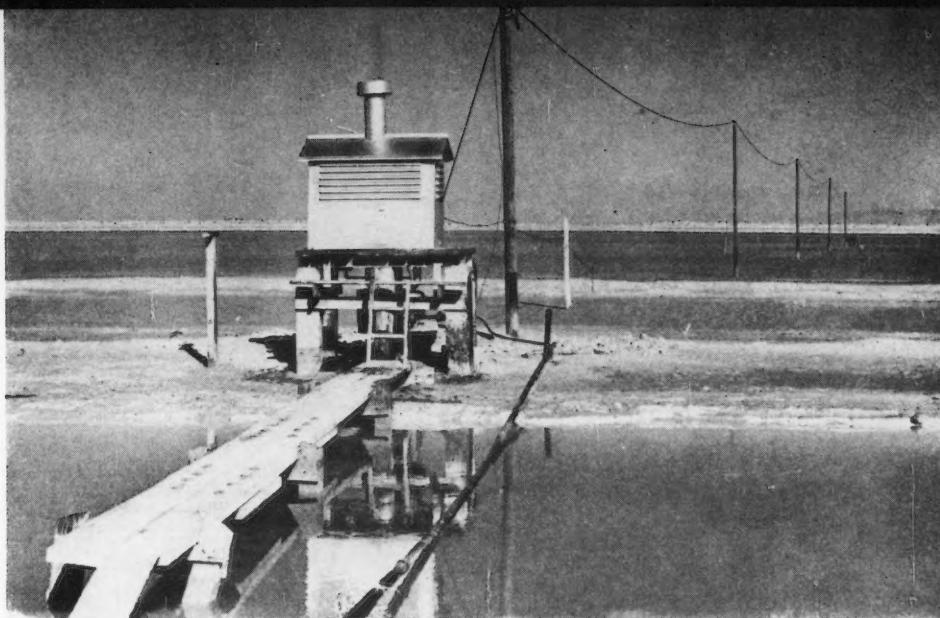


Figure 1—Jacobs Special two-cycle 2000-watt cathodic unit. Ground bed in background. Pipe lines protected: two 16-inch and one 26-inch.

Experience With Two Graphite Ground Beds In Dry Lakes*

By R. J. EMERSON*

THE SCOPE of this paper is a report on the performance of a ground bed which has been in operation for several years and on the problems encountered in the installation of a similar bed in similar ground.

The first of these beds is located at Salt Flats, Texas, ninety miles east of El Paso on U. S. Highway 62. The Salt Flat lake-bed is a typical western playa, a basin with no outlet, into which drain the sediments of many square miles. Adjacent to the flats are the large Guadalupe and Delaware mountain ranges which are mainly limestone with large strata of sandstone and gypsum and occasional small pockets of salt. About five miles from the ground bed in question salt has been produced by evaporation of salt water from shallow wells for over a hundred years.

Although there is only occasional surface water on this lake bed the earth is continuously wet a few inches beneath. An analysis of a pool of drain water alongside the highway (shown in the foreground of Figure 1) is given in Table I. The very high content of dissolved salts furnishes a very conductive electrolyte. The water tested neutral to Fisher pH litmus paper as did the soil. As was to be expected the soil immediately adjacent to the anodes tested extremely acid. The large quantity of chlorine gas liberated by the anodes has made the backfill yellow.

*A paper presented at the South Central Regional Meeting of the National Association of Corrosion Engineers at Dallas, Texas, October 3-4, 1949.

* El Paso Natural Gas Co., El Paso, Texas.

Placed in this environment is a ground bed of sixteen 2 inch x 80 inch and two 4 inch x 80 inch special treated graphite rods arranged in a straight line, spaced six to ten feet apart and backfilled with the surrounding soil. (Figure 2). The usual load on this bed of 15 volts and 70 amperes amounts to an average current density of 1.06 amperes per sq. ft. of anode surface which is quite high. The manufacturer's recommended current density is 0.25 amperes per sq. ft. with earth backfill and 1.00 amperes per sq. ft. with carbonaceous backfill or with sea water.

The output of each rod was measured and found to range from 0.88 to 1.52 amperes per sq. ft. These values together with the age of the anodes are listed in Table II. The four marked with asterisks were pulled for inspection and No. 18 was found to be consumed—Figure 3. The others are in good condition except for a few shallow gouges and slight tapering toward the bottom ends. Figures 4 and 5. They will apparently last for some time. With such homo-

TABLE I—Analysis of Drain Water at Salt Flats, Texas
Cathodic Protection Station No. 30

As parts per million

	Total hardness as CaCO_3	2393	Anion as Milli-Equivalents
Calcium as CaCO_3	2300	Calcium Ca.....	77.0
Magnesium as CaCO_3	93	Magnesium Mg.....	7.5
P Alkalinity as CaCO_3	0		
Total Alkalinity as CaCO_3	30		
Chloride as Cl.....	12460	Cations as Milli-Equivalents	
Sulfate as SO_4	4600	Chlorides.....	356.1
Silica as SiO_2	5	Sulphates.....	93.7
Iron as Fe.....	Trace	Bicarbonates.....	
Total Solids.....	25650		

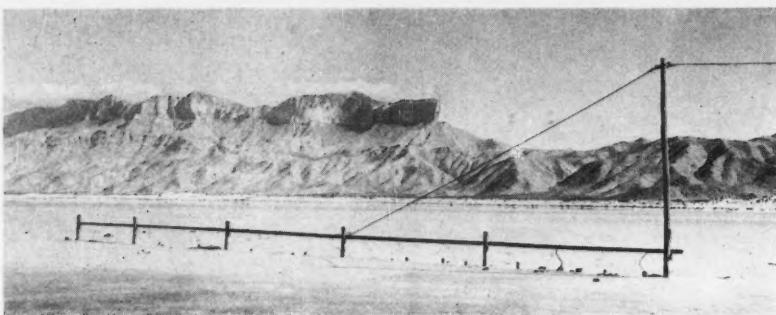


Figure 2—Salt Flat Ground Bed consisting of two 4-inch by 80-inch and sixteen 2-inch by 80-inch special treated graphite anodes.



Figure 3—Anode No. 18—the only one found to have failed.

geneous ground we cannot explain why No. 18 anode failed and the rest seem to be doing well.

The power supply is a Jacobs Special two-cycle 2000-watt, cathodic unit. The 0.21 ohm total circuit resistance includes a 0.10 resistor necessary for sufficient generator field coil voltage. The fact that the power source is an engine may suggest to many with experience that the unit may have been out of operation for a considerable portion of the time. However, the records for the past three and a half years indicate that it was down not over 10 percent of the time. Incidentally, the best record of continuous operation by this engine is five months without a minor breakdown.

With such low ground bed resistance and long anode life at Salt Flats we anticipated no trouble at another dry lake near Willcox, Arizona. To the eye this flat is very similar and it meggered approxi-

TABLE II—Cathodic Protection Station No. 30—Salt Flats, Texas
Load distribution of 71 Amps Applied to 18 Special Treated Graphite Rods
(Earth Backfill)

No.	Age	Size	Amps.	Amps./Sq. Ft.
1*	3 1/2 years	4" x 80"	7.96	1.14
2	5 1/2 years	2" x 80"	3.09	0.88
3	5 1/2 years	2" x 80"	1.21	0.35
4	5 1/2 years	2" x 80"	4.21	1.20
5	5 1/2 years	2" x 80"	3.46	0.99
6	5 1/2 years	2" x 80"	3.46	0.99
7	5 1/2 years	2" x 80"	3.84	1.10
8	5 1/2 years	2" x 80"	3.09	0.88
9	3 1/2 years	4" x 80"	5.34	0.76
10	3 1/2 years	2" x 80"	3.22	1.09
11	5 1/2 years	2" x 80"	4.21	1.20
12*	5 1/2 years	2" x 80"	5.34	1.52
13	5 1/2 years	2" x 80"	3.84	1.10
14	5 1/2 years	2" x 80"	4.21	1.20
15	5 1/2 years	2" x 80"	4.21	1.20
16	5 1/2 years	2" x 80"	4.96	1.42
17*	5 1/2 years	2" x 80"	4.59	1.31
18*	5 1/2 years	2" x 80"	0.56	...
			71.40	

Excluding No. 18, Average Current Density is 1.06 Amps./Sq. Ft. Average output of unit is 15 Volts 70 Amps.—0.21 Ohms.

mately 400 ohms/cm³. The installation crew found a top two foot layer of soil that is very hard and dry and underneath a gummy clay that is light blue-grey in color. Twenty 4 inch x 80 inch special treated graphite rods were installed with 25 lb. of lime and 25 lb. of aquagel mixed with the earth backfill. Upon applying current with a test generator the total circuit resistance increased rapidly from 0.6 ohms to 5.0 ohms within a period of twenty hours.

In an effort to determine the trouble, a miniature ground bed was built in a wooden box containing the Willcox soil. Anodes were carbon rods from flashlight batteries and the current density was doubled in order to speed up the test. Beginning with the soil wet, the resistance increased rapidly, much chlorine was liberated and the soil dried out leaving large cracks. Before the soil dried out completely the resistance could be brought down sharply, though temporarily, by punching small holes in the soil close to the anode. So it seemed conclusive that the problem was simply gas blocking. In other words, the soil is so dense that gases generated at the anode could not escape. As expected we attained good re-



Figure 4—Anode No. 1. Age: 3 1/2 years. Current density: 1.14 amp/sq. ft. Size: 4 inches by 80 inches.

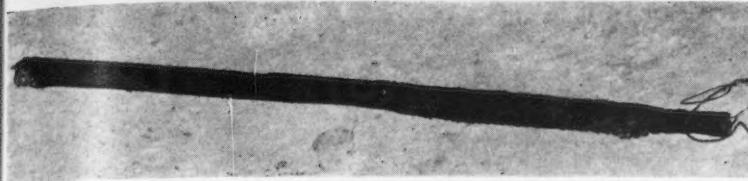


Figure 5—Anode No. 12. Age 5 1/4 years. Current density: 1.52 amp/sq. ft. Size: 2 inches by 80 inches.

sults by backfilling these model anodes with coke breeze. By this time we realized the importance of soil texture. The Salt Flats soil is coarse and sand-like, whereas the Willcox soil is very fine and dense.

To be sure that coke breeze backfill was the solution to the problem, four anodes of the full sized bed were pulled up and reset with well tamped coke breeze. Eight amperes (0.28 amps/sq. ft.) were applied and the resistance increased very little after 22 hours as shown in Figure 6. The load was then increased to 28 amperes (1.00 amps/sq. ft.) for another 22 hours and an even lower curve resulted. For the purpose of comparison, 10 amperes (0.28 amps/sq. ft.) were applied to five rods as originally installed and the resistance increased from 1.1 ohms to 10.0 ohms in 22 hours.

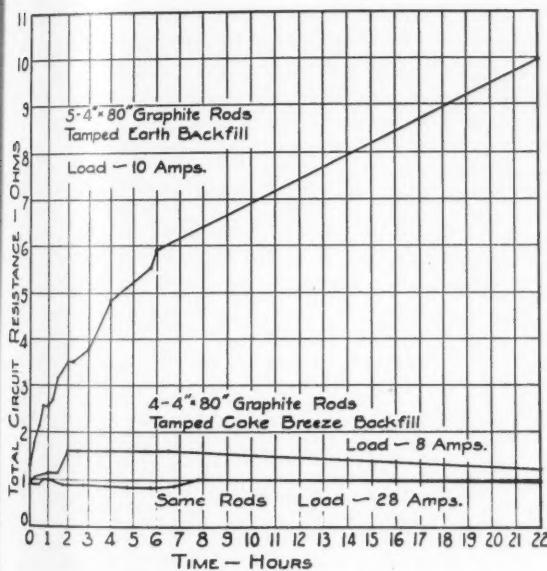


Figure 6—Backfill test cathodic protection station No. 65, Willcox Dry Lake.

In addition to the above readings resistance to remote earth of each anode was measured before and after the application of current. The coke breeze backfilled rods averaged 2.69 ohms before and 2.64 ohms after the test, whereas the earth plus lime backfilled rods averaged 5 ohms before and 24 ohms after. These figures are shown in Figure 7.

In conclusion, the two ground bed installations described furnish a marked contrast in the need for carbonaceous backfill around graphite anodes. The first operates very well without it whereas the second would not function at all without it. It is not known whether the fine texture of the Willcox soil is entirely responsible for this severe case of gas blocking. Red clay, which also appears to be fine and dense, is generally excellent for ground bed sites.

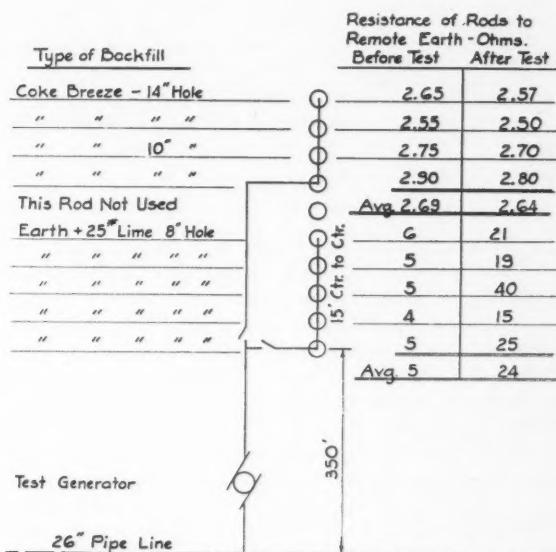


Figure 7—Willcox Dry Lake. All rods 4-inch by 80-inch graphite. All backfill well tamped.

Non-Metallic Lining Materials for Process Vessels In the Pulp and Paper Industry*

By BEAUMONT THOMAS*

Abstract

Non-metallic tank lining materials may be roughly divided into ceramic materials, which may be ordinarily used in thicknesses of from 1" to 8" and organic membrane materials which are used in thicknesses of from $\frac{1}{8}$ " to $\frac{3}{8}$ ". Linings of either type should be engineered according to the specific requirements of each application with full consideration of all the physical and chemical properties of the materials and the mechanical or structural requirements of the vessel. Ceramic linings are used for practically every type of process vessel in the pulp and paper industry. This involves the need for several types of ceramic material and bonding mortars; no single type of ceramic or mortar being suitable for all conditions. Several types of rubber linings, synthetic resin linings and other organic materials are also used but their use is restricted mainly by the large size of much of the equipment, their comparatively low heat resistance and limited chemical resistance. Combinations of the two types of linings serve to extend the applicability of both so that practically all lining problems can be satisfactorily solved.

Introduction

IN REFERENCE to process equipment, the term "lining" connotes a protective of substantial thickness which is subjected to corrosive or abrasive process materials under conditions of total and continuous immersion or exposure. This precludes consideration of that broad class of maintenance coatings and paints which are valuable in preventing external corrosion by ordinary atmospheric factors, corrosive plant fumes and spillage.

There is some overlapping of the two classes of materials and some materials of the latter class might occasionally be used for temporary protection but are usually inadequate when any degree of permanence and reliability is required. It is necessary to further limit the present considerations to those linings which are applied to larger equipment which, for the most part, may be classed as vessels or tanks.

Many of the requirements and problems involved in the lining of pipe, pumps, valves, fittings and such items of the smaller size on the one hand, and in the lining of the larger equipment on the other hand are specific and the two classes of equipment might therefore be better treated separately.

In the manufacture of pulp and paper, gases, solutions, suspensions and slurries are handled in very large volumes so that relatively large vessels and

equipment and relatively rapid flow rates are frequently required. Pulp digesters reach dimensions of 19 feet in diameter by 65 feet in height. Some blow chests have a capacity of 25,000 cubic feet and stock chests may have double that capacity. Bleach towers may reach dimensions of 16 feet in diameter by 60 feet in height. The materials or solutions handled in the various vessels may be strongly or weakly acidic, strongly or weakly alkaline, or practically neutral. They may or may not be abrasive and temperatures encountered may reach 2000° F. or higher in the case of gases and 400° F. in the case of liquids. A wide variety of linings is therefore required to prevent corrosion and wear of equipment and to prevent contamination of the process materials by corrosion products. Linings are also contributory in the maintenance of general cleanliness, such as in slime control which is being given increasing attention.

Thick or Heavy-Type Linings

Non-metallic linings may be divided roughly into two classes according to the methods of application. The thicker and heavier types of lining which consist of various ceramic and carbon materials are placed piece by piece and jointed with a mortar selected in accordance with service requirements. Lining thicknesses may be from 1 to 8 inches or even more.

Ceramic and carbon linings require little or no treatment such as curing, vulcanizing or baking following installation and prior to service and usually are field applied. They are not limited by the large size of much of the equipment to be lined and, with due allowances in certain cases, can be applied successfully to steel, concrete or wood surfaces. Cost is usually comparatively low, maintenance is low, repair is easily made and they will withstand considerable mechanical abuse. These linings are relatively massive and heavy and it is necessary to consider the design, construction and preparation of the shell or vessel to be lined.

It is frequently necessary, especially for concrete and wood vessels, to design the vessels to accommodate and support the lining, because the lining does not contribute to the strength of the vessel.

Materials for this type of lining are available to satisfy practically all heat conditions encountered in the pulp and paper industry. However, proper consideration of the thermal expansion and conductivity characteristics of both the lining materials and the shell material is required along with the thermal

* A paper presented at the Fifth Annual Conference, National Association of Corrosion Engineers, Cincinnati, Ohio, April 11-14, 1949.

* Chief Chemist, Stebbins Engineering & Mfg. Co., Watertown, New York.

TABLE I—Thermal Expansion & Thermal Conductivity of Lining Materials

MATERIALS	Thermal Expansion Per °F. Coef. x 10 ⁶	Thermal Conductivity B.t.u./Hr./ Sq. Ft./°F./In. Thickness
Steel	6.36	4.8
White Tile	2.4—4.2	4.8—9.2
Structural Clay Tile	2.0—4.1	4.8—9.2
Stoneware	1.9—2.6	7.0—18.0
Porcelain	2.3—2.6	7.0—8.4
"Acid Brick"	2.7—3.5	7.0—7.5
"Digester Brick"	2.9—3.2	4.7—6.0
Fireclay Refractory Brick	2.5—4.5	7.2—12.1
High Alumina Brick	3.0—4.4	7.2—24.0
Silica Brick	4.6—14.5	9.0—15.0
Carbon Brick	1.3—2.6	36.0
Common Brick	5.3	4.5
Neat Portland Cement		6.0
Portland Cement Mortars	5.0—6.5	2.3—9.5
Concrete	5.6—7.9	5.0—11.0
Silicate Cements	6.3	
Phenol-Formaldehyde Cements	6.4—17.2	2.4—5.0
Sulfite Cements	8.3	
Furan Resin Cements	11.2—17.1	4.7—7.7
Litharge-Glycerine Cements	7.0—11.5	8.5—12.0
Natural Rubber, Soft	36.0—60.0	0.9—1.2
Natural Rubber Hard	35.0—47.0	1.0—1.6
Asphalt	120—200	1.2—5.2
Polyvinyl Chloride	40—90	1.0
Vinyl Chloride Acetate Resins	80—110	1.0
Vinylidene Chloride Resins	1.1—9.5	0.7—1.4
Wood, parallel to fiber	18.0—61.4	0.7—1.4

shock resistance of the lining materials to properly fit a lining for service under high heat or varying heat conditions. Table I shows the thermal expansion and thermal conductivity of various lining materials that are used. The thermal expansion of steel is given for comparison.

Thin Linings

The second class of non-metallic linings includes those consisting of, or based upon hard and soft rubber, synthetic rubbers, modified rubber compositions, rubber latexes, synthetic resins, rubberized or plasticized bituminous or asphaltic materials and others. These are placed as continuous films in thicknesses considerably less than one inch and usually in thicknesses of $\frac{1}{8}$ to $\frac{3}{8}$ inch. They may be applied in sheet form in which no solvents are involved. They may be applied as multiple coats in liquids of brush or spray consistency, and in paste or putty form of troweling consistency. A few materials are applied by melting and pouring, flowing or swabbing in place. They are not all applicable to all types of surfaces.

The successful application of some of these materials requires very meticulous preparation of the basic surface and some treatment such as heat curing, vulcanizing or baking following installation so that shop application frequently has been necessary. The application of many of the materials has therefore been limited, up to now at least, to the smaller vessels. All of these materials are seriously restricted by low heat resistance, few being of any value for service at or above the boiling point of water. The harder and non-elastic materials are usually more heat resistant than the softer elastic or resilient materials, but the thermal expansion characteristics are such that no very great difference exists in the service limits of hard and soft materials.

Large differences in the coefficients of thermal expansion between the resilient materials and the base materials are usually compensated for ade-

quately by the "stretch" of the materials, at least within the range of serviceability. Whereas the wear resistance and impact shock resistance of rubber and many of the resilient materials is excellent, the hard surface materials offer little resistance to wear and mechanical abuse. In contrast with the heavier ceramic linings, these relatively thin linings do not ordinarily impose any special structural requirements on the vessel to be lined. It should be realized, however, that no lining, thick or thin, is designed to correct or compensate for any structural deficiency in the vessel. Also, especially in the case of the solvent type compositions, the basic surface should be free of sharp edges, corners and intricate contours so that the required lining thickness can be held and also to reduce the chances of accelerated wear on the lining by the disruption of streamlined flow.

Importance of Proper Surface Preparation

For most linings (and this is true for ceramic as well as organic materials), preparation of the basic surface is of prime importance, not only in providing proper adhesion but also in eliminating some of the causes for "pinholing," seepage, and permeation or diffusion through the linings. Unsatisfactory surface preparation along with indiscriminate use of many proprietary compositions of brush, spray and troweling consistency frequently has caused poor results so that a prejudice has to some extent been built up against some of the newer materials.

Suppliers sometimes have contributed to this by over-sensationalizing the product, by failing to distinguish between a lining material and a maintenance coating, and by failing to properly emphasize all application requirements. For example, application instructions frequently are found which recommend a certain method of surface preparation as preferable, but which also recommends other methods as acceptable. Now it seems that if there is any basis for preference for sandblasting, for instance, that is also the basis for necessity of sandblasting. Reliability of service depends on it, because an imperfection and resultant failure in a lining is much more likely to involve serious damage and costly repair than a readily discovered and easily repaired failure in an exterior coating. The successful application of these proprietary compositions also depends upon the applicator's understanding of such things as what an absolutely oil free surface is, or what complete evaporation of the solvent vehicle means.

Causes of Failure of Organic Linings

An important consideration in connection with the organic type linings is that of the possibility of diffusion. Solutions frequently will diffuse through a material whose absorptiveness in such a solution is very low. Such diffusion will cause blistering, loss of bond, stripping and serious corrosion of the base material. The phenomenon can be explained in some cases in accordance with the theories of osmosis and electroendosmosis and can be avoided largely by more nearly perfect surface preparation and by proper formulation of the lining materials.

There are however many cases of diffusion which

cannot be so explained. Some materials seem to be strangely selective in their behavior. A film may be impervious to some solutions over the full temperature range. To other solutions the film may be impervious at the lower temperatures but readily permeated at higher temperatures. In still other solutions it may be permeated at various rates at all operating temperatures, even though the material remains chemically unchanged in all cases.

A good demonstration of such behavior was observed in experimental work on neoprene films of 3/16-inch thickness, formed from a troweling composition. These films were applied on the inside surfaces of small autoclaves which had been prepared by sandblasting. The applied films were fully cured and resistant to heat up to a temperature of 250° F. No loosening of the film occurred in 10 percent sulfuric acid or in water at any temperature up to 220° F. during a period of four months. In a second autoclave no loosening of the film occurred in a 4 percent solution of sulfuric acid at room temperature over a period of four months. When the same lining was subjected to an equivalent solution blown into the vessel at 220° F. and under pressure, the film was completely loosened from the shell and could be stripped off easily exposing a surface on which corrosion had taken place.

In this test the solution was allowed to cool gradually during a period of four hours after being blown into the autoclave. Then the procedure was repeated and the lining was subjected to two such operations per day for five days before inspection was made. In hydrochloric acid of 22 percent strength, it was found that the film was blistered and/or loosened both at the lower and higher temperatures, the rate of loosening being faster at the higher temperature and the effect being less severe, but noticeable at the lower temperature.

Choice of Linings

The choice of a lining then is dependent on many factors besides chemical inertness. There is a tendency, in fact, to consult tables of chemical resistances of materials and to base a choice mainly upon such tables. Actually the most difficult problems connected with the specification of linings are more often related to the physical and physico-chemical properties of the materials, to the mechanical application of the materials and to the mechanical design of the equipment and lining as a unit. A lining is primarily a protective and its ability to resist corrosion is secondary to its ability to prevent corrosion. Under certain conditions, in fact, a material may be reacted upon but still provide adequate protection because the products of reaction are more resistant than the original material.

An example of this is rubber in contact with chlorine solutions. Soft rubber is fairly readily chlorinated with the formation of a resistant hard, non-elastic tenacious film, the thickness of which increases very slowly in the weaker chlorine solutions. Cracks which might form in the hard film do not extend any farther than the depth to which chlorination has taken place. Another example is the chlorination of

the phenol-formaldehyde resin cements which frequently are used as joint materials in tile linings in bleach plants. The resin cement is slowly chlorinated in the stronger chlorine solutions with the formation of an inert material which remains as an adequate protective, although a slight shrinkage which accompanies this change occasionally requires correction to prevent seepage.

To assure a good degree of permanence and reliability for trouble free service, every lining, whether of ceramic or organic materials, should be engineered in accordance with the particular conditions expected, and each set of conditions should be regarded as specific. When no experience or performance ratings exist, field tests should be instituted to supplement laboratory data. Application problems should be anticipated fully and design adjustments should be made to accommodate the requirements of both the lining and the process.

Use of Ceramic Linings

Ceramic linings of one type or another are found in almost every stage of pulp and paper making processes. The extent of their applicability is also being increased by constant improvements in materials, by many new joint materials, and by the combined use with the organic linings. Joint materials are available to satisfy almost any combination of chemical conditions.

By the combination of the thinner organic materials as membranes with brick or tile surfacing, the disadvantages of both materials for many applications are largely overcome. Very frequently the thickness of a ceramic lining and the danger of corrosion by seepage can be reduced by the use of a relatively thin membrane. A joint material, for example, which might be the most satisfactory for a particular set of requirements except for its high porosity might readily be used if a suitable membrane can be provided. Sometimes such membranes serve to compensate for design difficulties which cannot always be overcome.

On the other hand the service temperature limits of materials like rubber and vinyl resins can be greatly increased when faced with suitable ceramic linings, and the dangers of diffusion through the organic films can be practically eliminated when used even behind a relatively porous ceramic lining because no positive volume or pressure head of liquid contacts the film.

The thinnest and usually the cheapest type of ceramic lining consists of white glazed tile. This is a standard product but the denser and harder body tile with a highly craze-resistant glaze should be used. Various grades of porcelain tile are used occasionally.

Lining thicknesses for the white tile material are approximately one inch. White tile linings are not generally recommended where severely corrosive solutions or severe heat conditions might be encountered. They require a uniformly rigid basic structure and will withstand a limited amount of mechanical abuse. They are used to prevent wear of the basic material, to prevent contamination of the stock from

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steel or concrete surfaces, to promote cleanliness and smooth flow and to contribute towards good slime control. White tile linings are widely used for beaters, stock storage tanks, blending chests, white water tanks, machine chests and wire pits.

For rougher, more corrosive, or more erosive conditions and for the very large vessels, salt glazed stoneware and semi-stoneware and highly vitrified clay tile or blocks are used. These materials are hard, dense, practically impermeable, highly chemical and abrasion resistant. Bonding of mortars to such dense and highly glazed material often is a problem. Such materials do contribute however to smooth flow and cleanliness.

Lining thicknesses may reach three inches maximum. These materials are used with various joint materials in Jenssen acid towers, absorption towers, chlorinators, bleachers, acid settling tanks, stock chests and various other equipment. These linings will usually withstand a considerable amount of mechanical abuse and a moderate amount of heat and heat shock, but they do require a rigid supporting shell. Repair is easily made if attended to promptly and the linings are very long lasting.

The ceramic material generally recommended for very strong acid conditions is an "acid brick." This is a very dense, highly vitrified, and chemically resistant material. Acid brick linings are suitable for use in hot or cold acids but they do not have a very high degree of heat shock and spall resistance. Sharp temperature changes over a wide range are to be avoided therefore. For high operating temperatures, consideration must be given to relative expansions of shell and lining, especially in the case of rectangular or straight wall vessels. Acid brick linings very often are combined with organic membranes.

The ceramic generally preferred for service in hot acid liquors and under widely varying heat conditions is, in effect, a compromise between the highly vitrified, low porosity and low spall resistant acid brick and the porous but spall resistant refractory brick. This type of brick may be called semi-porous, its porosity being sufficient only to provide the accompanying desirable degree of spall resistance and flexibility and its chemical resistance being sufficient to resist serious disintegration by the acid liquors encountered. The properties of this brick can be varied within a certain range so that denser more highly vitrified brick may be used when the temperature conditions are less severe and when the acid conditions demand. Varieties of this type of brick are used for digester linings, acid accumulator linings, blowpit linings, and various other hot acid tank linings.

To complete the list of anticorrosive ceramic lining materials employed in the pulp and paper industry, mention should be made of the refractory lining materials used in sulfur burning and combustion equipment. This involves protection against hot acid gases rather than against aqueous solutions. Reduction of shell temperature by insulation is as important as protection against corrosion. The linings also have an important function in reducing contact with iron, iron oxides, and other iron compounds which

have an undesirable catalytic effect in transforming SO_2 to SO_3 . A wide variety of refractory and super-refractory materials are used, including various fire-clay refractories, high alumina refractories, and silica refractories. Various other materials such as the zircon refractories might have potential usefulness. The complete range of refractory mortars, castable and plastic refractories are used in conjunction with various refractory brick.

Use of Carbon and Graphite Linings

For service in high alkali and caustic alkali solutions at elevated temperatures the ceramic materials are of little or no value. Carbon and graphite materials have excellent chemical resistance to most acids and they are the only non-metallic materials which are unaffected by hot strongly alkaline liquors. These materials are being used to an increasing extent in linings for caustic cookers and alkali pulping digesters. Some carbon linings have now been in service in alkali pulp digesters for over fifteen years without any appreciable deterioration of the carbon. The main problems in connection with carbon linings for alkali pulp digesters involve the high thermal conductivity and low thermal expansion characteristics of the material. The tendency for separation of lining from shell has been difficult to overcome or to compensate for, especially because lining thicknesses are limited by the relatively high cost of carbon and by the size of the vessels.

In the smaller alkali pulp digesters reduction of capacity by linings is a greater factor than in the larger sulphite digesters. Recently a carbon brick has been produced which has a thermal expansion coefficient twice as great as any carbon brick previously available. Other properties of carbon brick have also been consistently improved so that lining design has been simplified to some extent and it has become possible to reduce lining thicknesses greatly, making wider application possibilities apparent.

Bonding or Jointing Materials

Of equal importance, in many respects, with the brick and tile in the heavier type linings are the bonding mortars or joint materials. No one joint material is applicable to all the various conditions and a joint material must be as carefully chosen as the ceramic material to be joined. Properties to be considered include chemical resistance, porosity and permeability, adhesion, heat resistance, thermal expansion, hardness, rigidity or flexibility, tensile and compressive strengths, permanence of properties, handling and working characteristics and cost. A growing list of chemically resistant mortars is serving to extend the versatility of ceramic linings. Many of these materials are serving not only as joint compounds but as impermeable linings between ceramic linings and between the ceramic and the basic surface.

Although Portland cement mortars have practically no resistance to acidic solutions, they should be included in any list of corrosion resistant joint materials. Compounded with various waterproofing and integral hardening materials they are extensively used under conditions involving neutral and alkaline

solutions. Specially formulated Portland cement mortars have been found to be suitable joint materials, in many cases, for carbon in counteracting hot strongly caustic solutions.

Silicate of soda cements consist essentially of a sodium silicate solution binder mixed with an inert powder filler which is usually a pulverized silica containing a setting agent. Silicate cements consisting only of silicate solution and quartz filler are available and are used. Such cements set initially by evaporation of water and gain their final set by contact with acids when placed in service. The type most frequently used is referred to as a quick-setting cement, there being a setting agent distributed in the powder filler so that hardening does not depend primarily upon evaporation of water and subsequent contact with acids. These cements have excellent resistance to strong acids and have high heat resistance, but they are very porous, and generally do not have satisfactory resistance to very dilute acids, water, steam and alkalis. The silicate cements are the cheapest of the acid resistant mortars and are the most easily used.

The synthetic resin base cements are of two main types, namely those based on phenol-formaldehyde resins and those based on furane resins. A liquid resin binder is usually mixed with a powder filler consisting of an inert material containing a hardening agent for the liquid resin. The inert filler may be finely powdered silica, carbon, barytes, or asbestos fiber. These materials are comparatively expensive but have a wide range of application and their use is increasing. The phenol-formaldehyde cements are resistant to most acids (mainly excepting oxidizing acids), to mild non-caustic alkaline solutions, and to many organic liquids and solvents; heat resistance is good, permeability is low and strength is high. The newer furane resin cements are resistant to all but oxidizing acids, to all alkaline solutions, and to practically all organic liquids and solvents; heat resistance is good, porosity and permeability are extremely low and strength is high. The handling and working characteristics of both types of the resin base ce-

ments can be adjusted to some extent to accommodate particular requirements. These cements can also be modified and reinforced to adapt them to a limited extent as continuous liners.

Other joint materials used occasionally in the pulp and paper industry include the sulfur cements and those plastic compositions formulated from solvent soluble bituminous and synthetic resin materials. The sulfur cements consist of plasticized sulfur with an inert powder filler. They are applied by melting and pouring. Various cements consisting of bituminous or synthetic resin base materials dissolved in solvents and mixed with silica, carbon or asbestos fillers to a paste-like consistency are supplied in a ready-to-use form. These cements set by volatilization of the solvent and their use is limited to few occasional and specific cases.

Finally, the litharge-glycerine cements are used to a large extent in sulfurous acid liquors in the pulp and paper industry. Litharge-glycerine cements have been standard joint materials in sulphite digester, acid accumulator, blowpit and hot acid tank linings for many years. Their use is a specific one applying particularly to sulfurous acid liquors, the cements having no wide range of chemical resistance. Besides having the desirable chemical resistance for the type of work referred to, these mortars have the required physical properties and the handling and working characteristics advantageous for this type of lining work. An approximate comparison of properties of the various joint materials including the properties of the litharge cements is given in Tables I, II and III.

Use of Non-Ceramic Linings

Of the non-ceramic linings, rubber materials have been the most widely used. For the most part, however, rubber linings in the pulp and paper industry have been for ducts, pipe, headboxes, valves, fittings and similar equipment.

The use of rubber in tank linings has not been extensive for three main reasons. First, the size of much of the equipment has precluded the possibility of shop application; second, a large number of the

TABLE II—Chemical Resistances of Joint Materials

	Portland Cement Mortars	Silicate Cements	Phenolic Resin Cements *	Furane Resin Cements	Sulphur Cements	Litharge Glycerine Cements
Sulphurous Acid Liquors	Poor	Fair	Excellent	Excellent	Excellent	Excellent
Acid Bleach Solutions	Poor	Fair	Fair to Good	Poor to Fair	Poor to Fair	Poor to Fair
Alkaline Bleach Solutions	Fair to Good	Poor	Poor to Good	Good to Excellent	Poor to Good	Poor
Water, Steam and Neutral Solutions	Good to Excellent	Poor to Fair	Excellent	Excellent	Excellent below 200° F.	Fair to Good
Mild Alkali Solutions	Good to Excellent	Poor to Fair	Fair to Excellent	Excellent	Fair to Good	Poor to Fair
Strong Caustic Alkali Solutions	Fair to Good	Poor	Poor to Fair	Excellent	Poor	Poor to Good
Strong Non-Oxidizing Acids	Poor	Excellent	Excellent	Excellent	Excellent	Poor to Fair
Strong Oxidizing Acids	Poor	Excellent	Poor to Fair	Poor to Fair	Poor to Good	Poor to Fair
Organic Solvents	Good	Excellent	Poor to Excellent	Excellent	Poor to Excellent	Poor to Excellent

TABLE III—Physical Properties of Joint Materials

	Portland Cement Mortars	Silicate Cements	Phenolic Resin Cements	Furane Resin Cements	Sulphur Cements	Litharge Glycerine Cements
Tensile Strength, p.s.i.	250-600	200-350	1200+	1400+	600-700	350-700
Compressive Strength, p.s.i.	4000-6000	2000-3000	6000-14000	8000-12000	6000-7000	4000-7000
Modulus of Rupture	600-1000	450-600	1000-2000	1400	1500-2000	700-1200
Adhesive Strength	Fair to Good	Fair to Good	Fair to Excellent	Fair to Excellent	Fair to Good	Fair to Excellent
Absorption, percent	3.0-8.0	Over 12.0	1.0-8.0	Less than 0.5	Less than 1.0	3.0-7.0
Permeability	Medium	High	Low	Very Low	Very Low	Medium
Temperature Limits, °F.	450-700	750-1600	350	375	200	450
Weight per Cu. Ft., Lbs.	130-140	120-130	110-125	95	140	180-225

vessels requiring protection are operated at temperatures beyond the range for rubber; and third, rubber is affected chemically to various degrees by chlorine and bleach solutions and tends to be permeated by sulphur dioxide or hot sulphurous acid liquors, bleach solutions and sulphurous acid solutions being among the most frequently encountered corrosives in the pulp and paper industry.

A few installations have been made, however, in which hard and soft rubber are combined as a dual lining, the hard rubber face having the necessary chemical resistance. Such linings have given satisfactory service in equipment handling chlorine and bleach solutions. The synthetic rubbers are subject to approximately the same limitations and adaptabilities as the natural rubbers. Butyl rubber is believed to be more resistant to sulphurous acid diffusion, but no performance records are available. Neoprene has greatly improved heat resistance in comparison with other rubbers and is comparatively resistant to sulphurous acid diffusion.

Several proprietary compositions based on natural and synthetic rubbers and on natural and synthetic latices are available. These may be of brush, spray or troweling consistency and may or may not require heat curing after application. The properties of the applied films might or might not equal the properties of the conventional rubber sheet linings. Neoprene compositions of this type have been used to some extent and have, for instance, given excellent service so far as linings for alum dissolving tanks where temperatures might exceed 212° F. with free sulphuric acid concentrations of over 2 percent.

In recent years synthetic resin lining materials have become fairly numerous and among these one of the main groups is based on the vinyl resins. In this group are included the various polymers and copolymers of vinyl chloride, vinyl acetate, and vinylidene chloride. These resins have been formulated into a number of sheet lining materials and liquid coating compositions. Many such materials are preferably shop applied while several other proprietary compositions are available for field or customer application.

The exact properties of films from such formulations based on identical resin components are not always alike and they vary with the formulating variations. Chemical resistances of the films are not necessarily identical with the chemical resistances of the original resin. The heat resistances of these materials are usually no better than the heat resistance of the rubber materials.

There is one outstanding property which sets some of these vinyl films apart from other organic materials in that they generally have good resistance to oxidizing acids or oxidizing solutions. No extensive use of them has been made as linings in the pulp and paper industry to date, but they likely will find greater adaptation in bleach plant work, especially in combination with ceramic linings.

Other synthetic resin lining materials are those based on phenol-formaldehyde resins. One type which has found some use in the pulp and paper industry consists essentially of incompletely con-

densed phenol-formaldehyde resin formulated to a spray consistency with volatile thinners. After application, the thinner is allowed to evaporate and the film is hardened and condensation completed by baking. Applications are best made on metal surfaces and field application on large areas is possible to some extent. Coating of pipe and smaller equipment is usually done as shop application. These coatings are comparatively hard and thin. They are not designed to withstand heavy impact shocks or any high degree of mechanical wear. The coating material does not undergo any deterioration by heat up to a temperature of 250° F., however the coating does break down in contact with hot solutions, probably because of differential expansion between lining and base material. In strongly alkaline solutions and in oxidizing or bleach solutions the material is fairly readily attacked.

No extensive tank lining work has been done using this type of material, but much auxiliary equipment such as pipe, valves, screen plates, flow boxes, pump cases have been lined with it. Where the material is applicable it does present a surface which prevents contamination of process materials and which contributes to cleanliness.

Other lining materials which are available, but which find only occasional if any use, include such coating compositions as those based on chlorinated rubber, the asphalts and various rubberized bituminous materials and the enamels or glass linings.

Chlorinated rubber compositions frequently are nothing more than coatings. Bituminous materials are not generally adapted to use in steel vessels and usually have low heat resistance with variable but definite plastic flow characteristics.

Glass or enamel linings are shop applied and the size of equipment which can be lined is therefore limited.

The newer silicone resins, polyethylene, and polytetrafluoroethane (Teflon) have received considerable publicity and considerable research work is being done to adapt these materials for use as coatings and linings. These materials have unusual chemical and heat resistances, but no satisfactory means of application and no satisfactory methods of bonding to other materials have been developed in the case of polyethylene and Teflon. Silicone varnishes are available but their application as lining materials has not been fully investigated so far.

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DISCUSSION

Comments by R. McFarland, Technical Director, Hills-McCanna Co., Chicago, Ill.:

Supplementing Mr. Thomas' remarks as to the use of Neoprene and rubber linings I believe that to satisfactorily resist corrosive service conditions in the pulp and paper industry, or in other process industries, it is necessary to specifically compound

special Neoprene or rubber stocks to secure the best service life. In other words, no particular Neoprene or rubber combination is ideally suited for general use. It should be stressed that each and every type of compound should be "tailor-made."

Extended service life of either Neoprene or rubber linings can be secured only by using sufficiently thick linings, in order to take into account the ever-present problem of diffusion and permeation that eventually will result in the contents working their way through unnecessarily thin layers of Neoprene or rubber that are, sometimes, mistakenly used in order to reduce the first-cost of the equipment.

Author's Reply:

It is thoroughly agreed that specific compounding of these materials is of great importance. It is also agreed that the rate of diffusion and permeation of solutions depends upon the thickness of the linings. Satisfactory thicknesses for some solutions might be quite inadequate for others. Also, for some solutions, thicknesses greater than are usually practical might be required to reduce permeation sufficiently.

The National Association of Corrosion Engineers Its Aims and Role in the Development of Experience in Combating Corrosion Problems*

By F. L. LaQUE*

BEFORE DISCUSSING the justification for the National Association of Corrosion Engineers, we might reasonably look into the history of technical societies in general. I understand that the first technical society in England and perhaps in the world, was the Institution of Civil Engineers which, of course, is still in existence. The members of this organization called themselves civil engineers to distinguish themselves from military engineers. Military engineering had developed naturally under governmental direction to superintend the building of waterways, roads, and bridges.

At the outset, the civil engineers were presumed to cover all the then known branches of engineering. But, as frequently happens in engineering societies, the direction in which their activities were concentrated was determined primarily by the interests of the leaders of the organization. In this case, the field of major interest happened to be that now occupied by civil engineering as we know it. This left another large group dissatisfied with the attention that was being given their particular interests along the lines of what we now recognize as mechanical engineering. So this group split off from the civil engineers and

set up a new institution of Mechanical Engineers. Through the course of years, the original omnibus organization gave way to the numerous technical societies that have sprung up.

These early developments more or less set the pattern for the creation of the hundreds of technical societies that have been organized during the past hundred years or so. Many of these new organizations have been started by groups that have split away from existing organizations where these have failed or were unable conveniently, to provide the attention that a particular more or less specialized branch of service in engineering had begun to require.

A common picture of this progressive sub-division of technical societies has been that the sub-division has followed and probably has been the inevitable result of progress in the several branches of science and engineering with the creation of fairly large groups of specialists in particular fields to form the nucleus of the new organizations. It has been natural that such specialists would become dissatisfied with the attention that could be given their particular needs and interests by the larger organizations.

The evolution of these specialized groups has not always involved the creation of new independent societies. In many cases, the result has been the organization of new divisions of the parent body as,

* Presented at a meeting of the Greater St. Louis Section, National Association of Corrosion Engineers, October 17, 1949.

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for example, in the case of the American Chemical Society, the Electrochemical Society and the American Society of Mechanical Engineers.

The organization of the NACE has fallen naturally into this common pattern. The first stage was the recognition of the importance of paying attention to corrosion in several of the older branches of science and engineering and the attraction or assignment to this field of activity of engineers or scientists originally trained or engaged in some other branch of engineering or science and who were members of one or more existing technical societies.

The organization needs of these specialists were and are served, at least in part, by the attention given to corrosion by many of the older societies. For example, the Industrial Division of the American Chemical Society has arranged symposia on corrosion, the Electrochemical Society has an active Corrosion Division; the American Society for Metals regularly has papers on corrosion in its programs;—so do the American Institute of Mining and Metallurgical Engineers; and the American Institute of Chemical Engineers. The American Society of Testing Materials has several committees concerned primarily with corrosion, particularly in the development of testing methods and the carrying out of extensive corrosion testing programs in what might be called natural environments, like the atmosphere and sea water; and the American Petroleum Institute also has several committees concerned with corrosion.

But in all of these societies, the attention given to corrosion represents only a fraction of the activity of the organization or involves only occasional and frequently casual consideration of corrosion as incidental to the principal field of interest.

The accumulation of a substantial number of engineers having a primary interest in corrosion, whose needs were not being satisfied by any of the existing technical societies, made it inevitable that sooner or later a special organization would have to be created to take care of their particular interests. But since there is no such thing as a general corrosion problem, it was almost inevitable that the nucleus of the new organization would be a group having some fairly well defined common concern with a particular problem of widespread interest.

It so happened that the nucleus around which the NACE was created was that group of progressive corrosion engineers in the Southwest who had the common problem of protecting against corrosion, the thousands of miles of underground pipe lines used for the transportation of gas and petroleum. They had the good sense to realize that they would accomplish more by working together than individually, and formed an organization to facilitate their joint efforts. At the outset, their group was attached for immediate convenience to an existing organization in the field of Electrical Engineering but they soon discovered that this organization was not prepared to give their special needs the attention they required. While their basic interest was fairly narrow with relation to the broad field of corrosion engineering, this group of corrosion engineers had the breadth of vision to realize that ultimately they could and

would benefit by association with corrosion engineers working in quite different parts of the general field. So, instead of calling themselves something like the Southwest Society of Pipe Line Protection Engineers, they chose to take on a greater field of interest, both geographically and technically and organized the National Association of Corrosion Engineers.

At the outset, some of those who had been concerned with corrosion in one or more of the older technical societies, were inclined to look upon this new group as upstarts and to feel that they were being presumptuous in calling themselves the National Association of Corrosion Engineers. There is also reason to believe that, at the same time, some of the organizers of the NACE were not aware of the activities in this field of some of these older groups and were inclined to feel that they were the only ones doing anything about corrosion in an organized way. Fortunately, these opportunities for the development of jealousies and friction did not develop into anything of consequence. Apparently, those who had a genuine interest in the profession of corrosion engineering realized that while the nucleus of the organization might be concerned with matters remote from their particular interests, it didn't matter so much what these interests were so long as the nucleus was sound and active. And so corrosion engineers from many fields and industries have been attracted to this sound and active nucleus of pipe line protection engineers to form the present NACE. It should be noted in passing that in its early stages, the NACE was careful to establish cordial relations with other organizations in this field. These relations have been formalized through the setting up of what is called the NACE Inter-Society Corrosion Committee, which is made up of delegates from several societies and governmental departments and which serves primarily to avoid friction and duplication of effort.

The rate of accretion of members to the NACE has been remarkable as indicated by the fact that each year the membership has increased by about 50 per cent. The natural result of this influx of members from many fields has been that the concentration of the original members on pipe line protection has been diluted by the varied interests of these other engineers. Perhaps there are some who view this development with some concern. But, in the long run, it will become evident to all that no matter how specific and narrow the interest of an individual member may be, he will benefit at least indirectly from activities of the Association that can be carried on and supported only by the pooled efforts and resources of a large number of engineers, irrespective of whether their particular interests are broad enough to touch directly upon his.

Furthermore, no matter how individual and specialized a corrosion problem may appear to be, there always is a good chance that a solution to it will be helped by application of data or experience developed in connection with some other apparently unrelated problem in some other industry.

And that brings us naturally to the major reason for the existence of any technical society, which is to provide a means of communication among people

having a common interest. If there are only a few people having such an interest, they can make their own arrangements to meet each other and exchange information at first hand, but as the number grows some other mechanism is required and the technical society provides that mechanism.

The ideal situation is where the exchange of information and comments is at first hand by conversation. Since this is rarely practical, the next best thing is at a relatively small meeting such as one of your sectional meetings where there is plenty of opportunity to cross-question the speaker and for any or all of those present to take part in the discussion and thus bring directly to bear a great variety of experience and data.

The more largely attended regional and national meetings tend to be more formal and discussion is likely to be somewhat more inhibited and restricted by limitations of the time that can be devoted to a particular paper or subject. There also is a tendency for the annual meeting papers to be written primarily by and for the more experienced engineers so that newcomers to the field may feel that the papers are over their heads. These individuals are likely to benefit most by attendance at local sectional meetings when they will have the added advantage of better opportunity to get acquainted with each other and with those old timers whom they may meet there.

Probably the principal purpose of the technical program at annual meetings is to describe major advances in the field for later publication and study.

And this then brings us to the second means of communication—by publication. Before the advent of the NACE publication, CORROSION, there was no journal on this continent devoted solely to the publication of papers and articles in this field, though papers on corrosion appear more or less spasmodically in other publications.

The high standards that have been set by the editor of CORROSION and its paper review committee have already given CORROSION an excellent reputation and are attracting authors to CORROSION as a desirable medium of publication for their best work.

In addition, the NACE has made arrangements for exceptionally complete coverage by abstracts of all important publications in the field of corrosion. This has been accomplished by securing the cooperation of 23 abstracting organizations on this continent and in Europe who each month send the Editor of CORROSION copies of their current abstracts of articles on corrosion. These are then combined and edited and published to provide the most complete coverage of the literature on corrosion that can be found anywhere.

This monthly publication of abstracts is being supplemented by the publication of annual bibliographies. Plans for the immediate future provide for the setting up of a classified index of abstracts designed to permit mechanical sorting by the McBee system. When this has been put into operation, it will be possible to secure abstracts printed on cards for filing and subsequent selection on the basis of several sub-divisions of interest. In addition to the

complete papers and abstracts published in CORROSION, there appear from time to time verbatim reprints or condensations of important articles that have been published elsewhere. The net result is that reference to CORROSION will permit any reader to keep well abreast of all the important developments in this field of science.

Another valuable feature of the publication CORROSION is its Questions and Answers section which provides a means by which any special corrosion problem may be brought directly to the attention of those who may have an answer or answers. A study of these questions and answers is bound to improve the general knowledge of the reader and perhaps permit him to recognize the cause and cure of some corrosion problem when it appears.

Finally the information provided on the editorial pages of the magazine is supplemented to excellent advantage by the data on products and their performance which are featured in the advertisements which provide the major portion of the revenue required to pay for printing the magazine.

It costs a good deal of money to publish a magazine like CORROSION and obviously an organization is required to arrange for the publication and to secure the advertising support to finance it. In this connection, it may be noted that the current cost of publication is over three times the total dues from the active members of the Association. So here we have concrete evidence of the value of the organization in multiplying the contributions of its individual members. It may be noted also that no particular group within the Association would be able to finance a publication of the calibre of CORROSION.

In addition to the publications already mentioned, the Association is engaged in providing additional published information in the form of books, like the combined papers in the NACE-ECS Symposium on Cathodic Protection. Because of the rather specialized interest in this subject, none of the publishers of technical books was willing to undertake publication of these papers in book form. So the NACE and the ECS had to arrange jointly for publication on their own account and while it is likely that eventually this venture will pay for itself and perhaps even show a profit, this undertaking represents a loss to date. This, then, is another example of something that required the existence of an organization like the NACE.

Another type of publication is the reports of the different technical committees being prepared for publication—one on galvanic anodes for cathodic protection, one on anodes for use with impressed current and one covering the results of a special study of metals and alloys to resist the peculiar corrosion encountered in condensate gas wells.

Reference to these reports leads naturally to one of the most important features of the NACE, viz. the activities of its technical committees. The purpose of each of these committees or sub-committees is to provide for organized attention to particular topics or special problems—new groups will be organized from time to time to take care of particular

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cases that may arise. The scope of the coverage of the field is indicated by the following titles of the several sub-committees now in action:

- TP-1—Corrosion of Oil & Gas Well Equipment
- TP-2—Galvanic Anodes for Cathodic Protection
- TP-3—Anodes for Impressed Currents
- TP-4—Minimum Current Requirements for Cathodic Protection
- TP-5—Corrosion Problems in Processing and Handling Chemicals
- TP-6—Protective Coatings
- TP-7—Materials for Use at High Temperatures
- TP-8—Corrosion by Waters
- TP-9—Corrosion Inhibitors
- TP-10—Corrosion Fatigue
- TP-11—Identification of Corrosion Products
- TP-12—Electrical Grounding Practices
- TP-13—Annual Losses Due to Corrosion

It seems safe to say that up to now the colleges and universities have provided generally inadequate and sometimes poor training for corrosion engineers.

The NACE is giving this matter some attention and has set up a special sub-committee to look into the matter. In addition, more direct action already has been taken by sponsoring what was a very successful intensive short course on Corrosion given under the direction of Dr. Norman Hackerman of the University of Texas in September. This attracted over 100 students from 19 states.

It may be assumed that a suggestion to organize a similar course elsewhere would receive appropriate consideration by the committee on education and that it might be possible to arrange for such a course designed to suit the particular interests and requirements of that area.

It will be observed that the NACE is organized to tackle corrosion problems in several ways and from several directions and the scope of its coverage and interests is illustrated very nicely by the program of papers which is presented at the yearly national conventions.

DISCUSSIONS ARE INVITED

Readers who wish to submit written information additive to articles published in *CORROSION*, or who wish to register differences of opinion with respect to any articles are urged to send such discussions to Dr. F. N. Alquist, Chairman, NACE Editorial Review Committee, Organic Research Laboratories, 20A Building, Dow Chemical Co., Midland, Mich. Doctor Alquist will submit such discussions to a member of the review committee, and after review and approval the discussion will be published.

The expression of opinions about or the addition of information to that contained in technical articles will advance the interests of NACE and make *CORROSION* more valuable to the membership.

Field and Laboratory Evaluation Of Petroleum-Base Rust Preventives*

By E. L. WALTERS* and R. G. LARSEN*

Abstract

Heretofore, petroleum-base rust preventives have been rated primarily on the basis of laboratory performance. This paper discusses the evaluation of such materials in the light of field performance under conventional conditions of exposure. The extensive scope of the investigation permits a statistical interpretation of the influence of atmospheric environment, composition, and application variables upon the performance characteristics of both rust-preventive coatings and films. Field and laboratory behavior are correlated and the limitations of each type of measurement are indicated.

A. Introduction

THE RUSTING of iron and ferrous alloys is an old problem and protection against rusting has long been achieved by use of non-ferrous metal coatings and paints. More recently,^{1,2} rust-preventive coatings and films derived from petroleum-base products have been used for this purpose, each type of protective medium having certain advantages and disadvantages. The more temporary action of the petroleum-base products, for example, is offset by such advantages as cheapness, ease of application or removal, and simultaneous protective and lubricating action.

Petroleum-base rust preventives, as described herein, are of two general types: coatings and films. Coatings form semi-solid or solid coverings of various thicknesses and are employed mainly for outdoor protective action; these are made from asphalt, petroleum, or wax, with or without solvents and additives. Films are lighter (more fluid) mixtures used mainly for indoor protection and are generally oil-additive combinations.

To date, the quality of petroleum-base rust preventives has generally been assessed on the basis of laboratory tests^{1,3} of the type also employed in fundamental studies.⁴ Limited data are available concerning the field performance of these products, owing to the rapidity of their development and the difficulty of reproducing field test conditions.

The purpose of this paper is to indicate the performance characteristics of typical petroleum-base products under field conditions more consistent than those normally encountered, to indicate the influence of climatic factors and application and composition variables on performance, and to provide insight into the relation between field and laboratory behavior. The data contained herein represent a summary of

extensive tests made over a two-year period on a variety of products previously known to exhibit widely varying laboratory behavior. Major emphasis in subsequent discussions is placed on field behavior.

Field-test locations were so chosen as to provide the optimum spread in atmospheric conditions and yet permit convenient operation from one base. Most of the tests were made at Oakland, California, a typical coastal industrial area, where temperatures are moderate and humidity variable, usually high. Tests were also made at Modesto, California, a typical inland area where summer temperatures were higher and humidities lower than at Oakland. Winter atmospheric conditions were similar at both locations and significant rainfall occurred only during the winter months. Representative atmospheric measurements for a portion of the test period are given in Figure 1.

B. Experimental Methods

I. General.

Insofar as possible, field and laboratory tests were made employing conventional equipment and conditions of exposure.^{1,3}

II. Outdoor and Shed Exposure.

a. **Equipment.** Figure 2 shows the outdoor and shed exposure units at Oakland. This equipment was constructed in accordance with U. S. Army-Navy specifications AN-C-52a, paragraphs F-4d(2)d, and F-4d(2)e, respectively. The "more protected" shed was similar to the above, except that all the louvers were baffled about 75 per cent to reduce air circulation.

b. **Application.** Rust-preventive coatings and films were applied conventionally unless otherwise indicated. Specimens for solid coatings were generally dipped at elevated temperatures, while those for solid-solvent blends were dipped at room temperature; all were drained for 20 hours at room temperature prior to test. Specimens for films were generally dipped for 1 minute at 70° F. and drained 20 hours at 130° F. prior to test.

All exposure tests were made in triplicate on polished or sandblasted panels (Figure 3), all from a common stock of SAE 1020 low-carbon steel. Polishing was done by hand, finishing with No. 320 sandpaper. Sandblasting was carried out in accordance with the procedure given in paragraph F-4-i(1) of U. S. Army Specifications 2-121.

Some coating tests were made on specially prepared steel rods (Figure 4) offering a variety of surfaces for protection. A few film tests were made on

*A paper delivered at the Fifth Annual Conference, National Association of Corrosion Engineers, Cincinnati, Ohio, April 11-14, 1949.

* Shell Development Co., Emeryville, Cal.

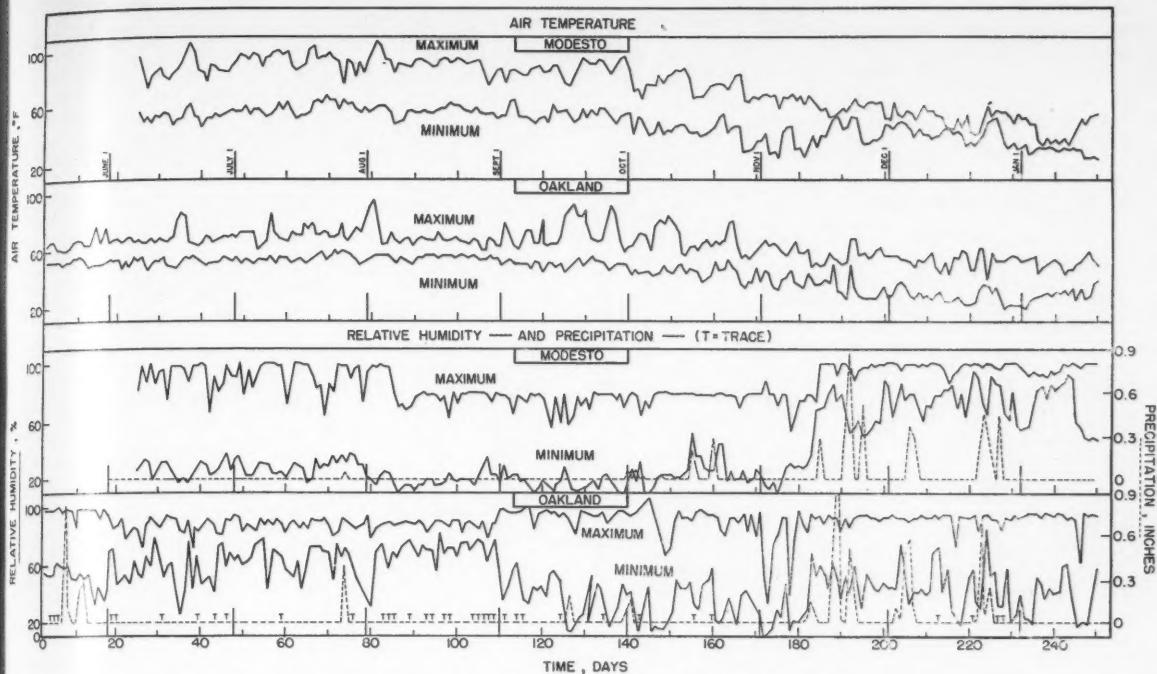


Figure 1—Atmospheric measurements at rust preventive test sites. May-January (Second Series).

nails. Rods and nails were precleaned by naphtha solvent washing and drying.

c. Ratings. All ratings were obtained by one operator to eliminate the personal factor. Ratings were made with rust preventives in place and subsequently confirmed on stripped panels, if necessary. Weekly records were kept of the following degrees of corrosion:

1) initial	(first signs)
2) light	(up to 5% of surface area rusted)
3) medium	(5-10% of surface area rusted)
4) heavy	(>10% of surface area rusted)

Tests were terminated at the point of heavy rusting.

Ratings on outdoor-exposure panels were generally made on the exposed sunward side. On shed exposure panels they were taken for the side affording poorest protection. In keeping with specifications, the outer $\frac{1}{8}$ -inch of all panels was disregarded, even though this portion generally rusted first. The entire area was rated for the special test specimens and nails.

Products were arbitrarily evaluated as follows: coatings affording over-all protection (<10 percent of surface area rusted) for more than 180 days were considered good; those between 90 and 180 days, fair; less than 90 days, poor. Films affording over-all protection of more than 90 days (series 1) or 100 days (series 2) were considered good, those between 45-90 or 50-100 days, fair, and those less than 45 or 50 days, poor.

The "over-all" protection times provided more consistent distinction between products than "complete" protective values.

III. Laboratory Tests

The essential features of all laboratory tests are given in Table I.

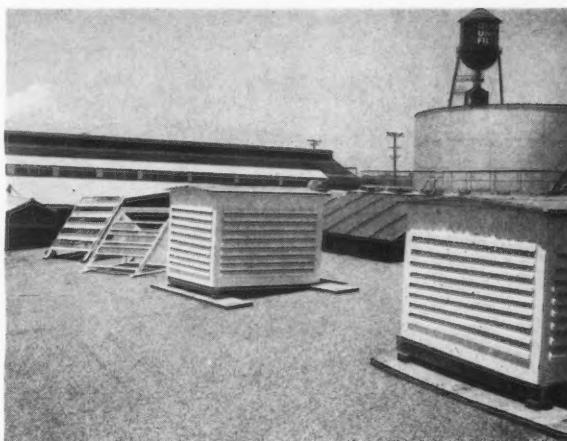


Figure 2—Outdoor and shed exposure units for rust preventive studies.

The Humidity Cabinet tests were made at 100° F. and 100 per cent relative humidity, employing a Rock Island Arsenal or home-made cabinet (Figure 5), which provided comparable results.

The combined Humidity Cabinet-Ultraviolet Light tests comprised a daily cycle of 19 hours (HC) and 5 hours (UV), disregarding week-end exposure periods in the humidity cabinet. The ultraviolet light exposures were conducted in accordance with paragraph F-4-i (2) of U. S. Army specifications 2-121.

The Water Drip test, shown in Figure 6, has been described previously.⁴

The Salt Spray test was conducted in accordance with ASTM procedure B-117-41T, employing a commercial test unit.

TABLE I—Laboratory Rust-Preventive Test Conditions

TEST	General Operating Conditions	APPLICATION VARIABLES				Type of Test Specimen	Basis of Evaluation		
		DIPPING		DRAINAGE					
		Time	Temperature	Time	Temperature				
Humidity Cabinet	100° F., 100% relative humidity, daily inspection				130-5° F.	Sand-blasted panels	Time for trace corrosion and/or 10% of surface rust		
Humidity Cabinet—Ultraviolet Light	Daily cycle 19 hours humidity cabinet (as above), 5 hours ultraviolet light exposure at 120° F.; daily inspection	1 minute in rust preventive	Varied: specified separately for each material	20 hours in air	Room temperature ca. 70° F.	Polished panels			
Salt Spray	95° F. 18-20% w/w salt spray, daily inspection					Sand-blasted panels	Average time for initial corrosion		
Water Drip	Multi drip apparatus, inclined specimen, 0.05 N NaCl continuous inspection								
Static Drop	10 static drops 0.05 N NaCl on flat specimen protected from atmosphere hourly inspection								
Synthetic Sea Water Immersion	Immersion in synthetic sea water for 20 hours, final inspection								
Water Displacement (Syn. Sea Water)	Pre-drip in synthetic sea water, dip in test material, remove, observe continuously during and after dipping	3 seconds in synthetic sea water followed by 1 min. in test material	Room temperature ca. 70° F.	24 hours (test period)	Room temperature ca. 70° F.	Sand-blasted rods	Pass = no corrosion, amount of corrosion also indicated in case of failure		
							Water displacement action fast (<20 seconds), medium (20-40 seconds) and slow (>60 seconds). Rusting at end of test indicated as none, light, medium or heavy		

TABLE II—Typical Outdoor Exposure Test Data on Rust-Preventive Coatings

BLEND	APPLICATION				AVERAGE EXPOSURE TEST RESULTS			LABORATORY TEST RESULTS		
	Dipping		Draining		Location	Time of Protection, Days		Salt Spray, Days	Combined HC-UV, Days	
	Time, Min.	Temp., °F.	Time, Hours	Temp., °F.		Com- plete	Light Rust		Com- plete	Over- all
Air-Blown Asphalt (10-20 Pen.)	50% v Aromatic	None			Oakland Modesto	43 57	93 57	93 57	7	20
		5% v-A	1	70	Oakland Modesto	43 57	43 57	93 57	8	18
		5% v-B			Oakland Modesto	65 78	65 78	65 78	6	14
		None	1	392	Oakland Modesto	192 148	192 148	192 148	14	..
		5% v-C			Oakland Modesto	199 184	247 184	247 184	16	..
	None	None			Oakland Modesto	185 46	> 233 > 236	> 233 > 236	24	20
		5% v-A			Oakland Modesto	> 239	> 239	> 239	29	..
		5% v-C			Oakland Modesto	> 239 > 239	> 239 > 239	> 239 > 239	25	..
		15% v Oil	Conglomerate 2% v	1 170 20 70	Oakland Modesto	219 123	219 236	> 233 > 236	23	40
		60% v Naphtha	None		Oakland Modesto	57 57	85 78	176 78	29	..
Short Residue Petrolatum	65% v Naphtha	5% v-A	1	70	Oakland Modesto	29 29	35 34	35 43	4	..
		5% v-B			Oakland Modesto	57 78	176 78	176 78	..	..
		75% v Aromatic	None		Oakland Modesto	35 43	35 43	35 43	5	..
	AXS-673 Blend		1 90 20 70		Oakland Modesto	191 186	> 233 186	> 233 186	20	..
					Oakland Modesto	218 186	218 186	218 186	24	49
USA2-121 Blend			1 185 20 70		Oakland Modesto	218 186	218 186	218 186	24	49
USA2-82C Blend			1 225 20 70		Oakland Modesto	51 202	177 202	218 236	14	50
ANC-52A Type 2 Bl.			1 210 20 70		Oakland Modesto	177 188	> 218 > 236	> 218 > 236	24	54
Na Base Grease		Hand Applied	0.003" Thick		Oakland Modesto	72 81	72 81	72 81	3	..
Li Base Grease		Hand Applied	0.003" Thick		Oakland Modesto	100 46	100 95	149 95	3	..
Al Base Grease		Hand Applied	0.003" Thick		Oakland Modesto	100 95	100 95	100 95	3	..

*A—Lead Naphthenate, B—Petroleum Sulfonate, C—Wax.

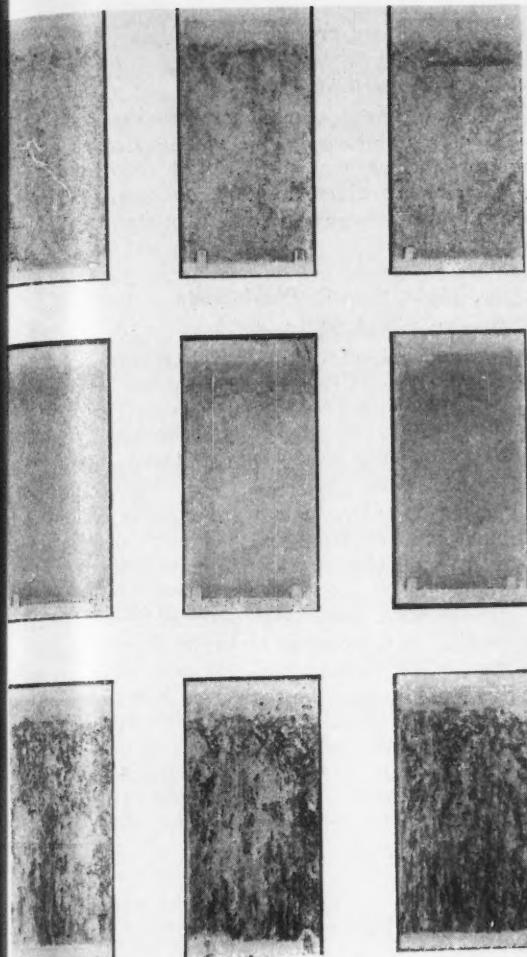


Figure 3—Typical panel specimens. Triplicate tests on coatings.

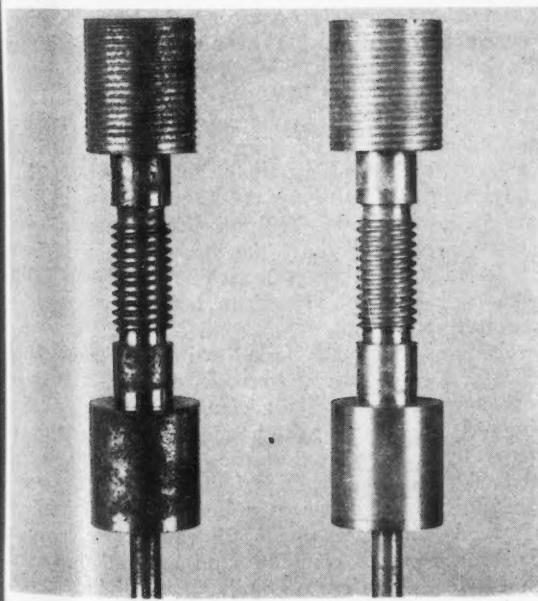


Figure 4—Special test rods for outdoor exposure tests. Top—Coarse machined. Center—Threaded. Bottom—Fine Machined.

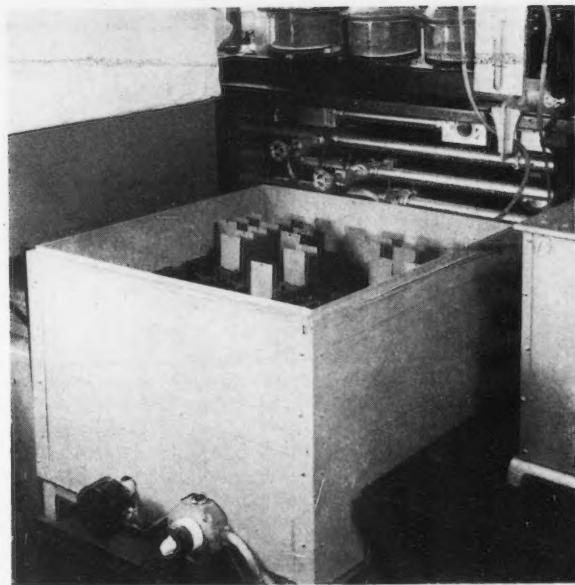


Figure 5—Emeryville humidity cabinet.

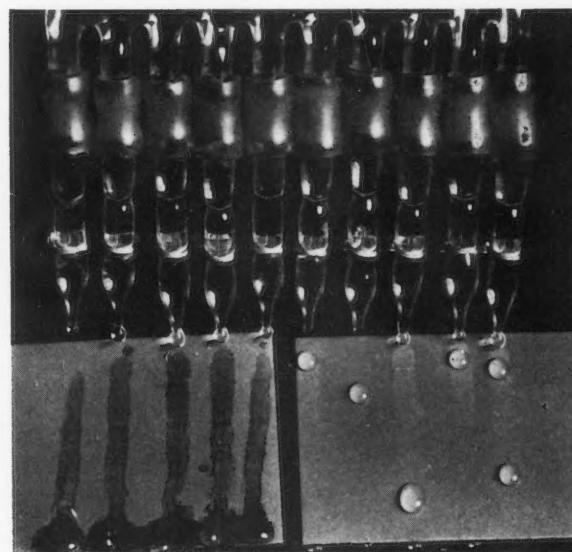


Figure 6—Water drip test apparatus.

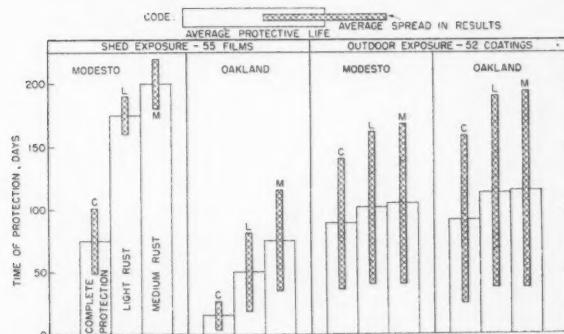


Figure 7—Comparative rust protective action at Oakland and Modesto. (C—Time of complete protection. L—Light rust. M—Medium rust.)

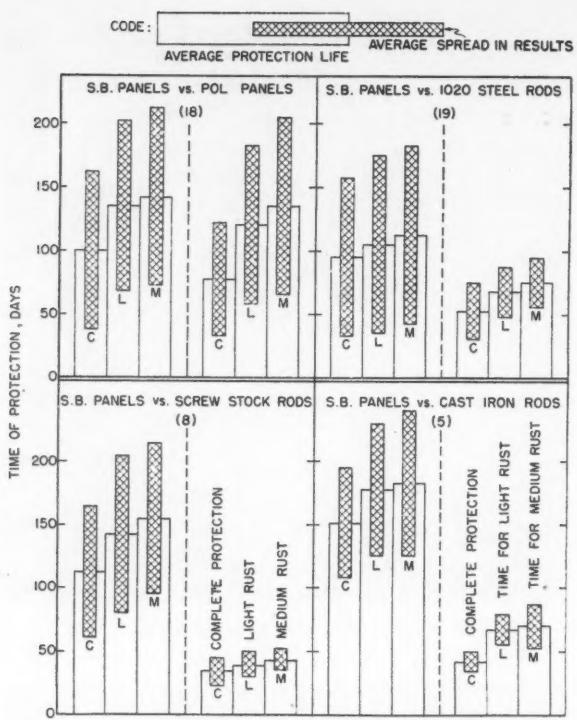


Figure 8—Comparative rust preventive action of coatings on various types of surfaces in outdoor exposure at Oakland. (C—Complete protection. L—Light rust. M—Medium rust.)

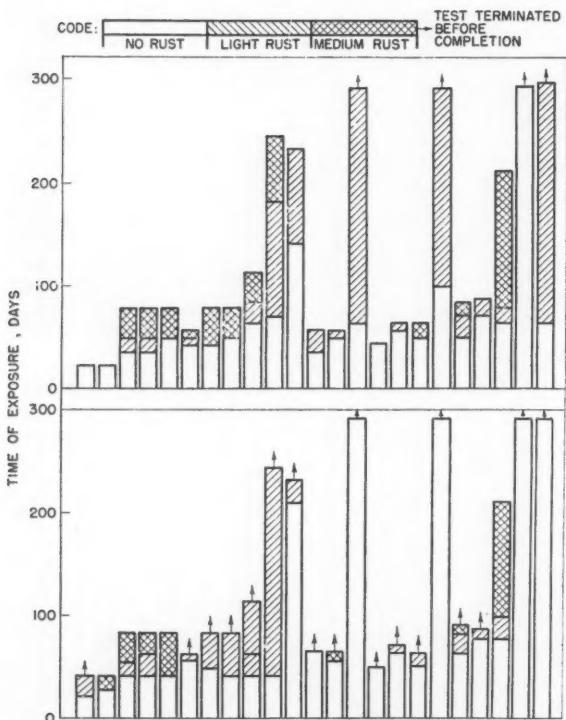


Figure 9—Comparative degree of protective action on exposed and under side for rust-preventive coatings at Oakland. (First series.)

The above were found to constitute the more pertinent laboratory procedures.

IV. Control Panel Studies

Clean uncoated specimens were exposed for periods of approximately one week outdoors and one month in shed exposure. Visual corrosion ratings were made as above and, in addition, quantitative measurements were made using an electrolytic cleaning procedure.

C. Field Tests

I. Rust-Preventive Coatings

a. **Test Variables and General Observations.** Coatings were generally tested under conditions of intended usage, i.e., outdoor exposure. Test variables studied include the effects of atmospheric environment, method of application and exposure, coating thickness and composition, and type of protective surface. Generally, tests were commenced in early summer. Figure 3 provides an example of outdoor exposure and shows that triplicate tests were quite reproducible.

Rust-preventive coatings afforded equal degrees of protection in the coastal and inland areas, as shown in Figure 7. Presumably, the more corrosive effect of higher humidity on the coast was offset by increased drainage (thinner films) at the higher inland temperatures. Coastal exposure at similar temperatures but higher humidity would be expected to be more severe. Conversely, inland exposure at a similar humidity but lower temperature would be expected to be less severe.

At both locations, coatings afforded equal degrees of protective action on polished or sandblasted panels, typical data being shown in Figure 8. The first evidences of corrosion occurred equally rapidly on exposed or sheltered (underside) surfaces as shown in Figure 9, but subsequent corrosion progressed more rapidly on the exposed side. The protective action of coatings was much greater in shed (inside) exposure than in direct outdoors exposure, as shown in Figure 10.

Panel surfaces were more readily protected than special machined rods (Figure 8), although the difference may be due in part to the fact that the entire rod was rated but only the central portion of the panels. For the rods, the fine machined sections were most difficult to protect, the threaded sections intermediate, and the coarse machined sections easiest. The type of steel proved to be of secondary importance.

Coatings eventually failed owing to the combined effects of reticulation, drainage, erosion, and chemical change. Greases failed because of oil depletion due to evaporation or drainage. For panels, corrosion generally occurred first on the top or windward edge and was preceded by visual disintegration. Precipitation did not appear to affect the rate of failure. However, failure was generally rapid once corrosion had commenced; complete and over-all protection times were therefore of similar magnitude.

The various products tested showed a widespread variation in field behavior (c.f. Figures 8 and 9), sug-

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gesting that such differences might be assessed on the basis of laboratory tests.

b. Protective Action of Coatings. The field performance of some of the better coating-type rust preventives at Oakland is shown in Figure 11 and examples of detailed inspection data are given in Table II.

The uncoated (blank) panels corroded rapidly whereas the more effective coatings afforded several months complete protection and up to one year overall protection. A widespread difference was noted in the performance characteristics of different products.

The action of coatings is mainly mechanical, thicker ones affording greater protection. However, solid constituents varied in behavior. Thus, petroleum-wax blends generally proved superior to asphalt blends of comparable thickness and air-blown asphalts were better than steam refined products. Additives generally contributed little protective action, as shown in Figure 12.

Greases gave only moderate protective action under the limited conditions of test (0.003 inch thickness of grease on polished panels) but thicker coatings would likely have proved more effective. There was no simple relation between the protective action of greases and their commonly accepted water-solubility characteristics.

Commercial rust-preventive coatings gave consistently "good" field performance in outdoor exposure, as shown in Figure 13.

All coatings gave better protection for tests commenced during a prolonged dry period. Fresh coating compositions sometimes indicated better protective

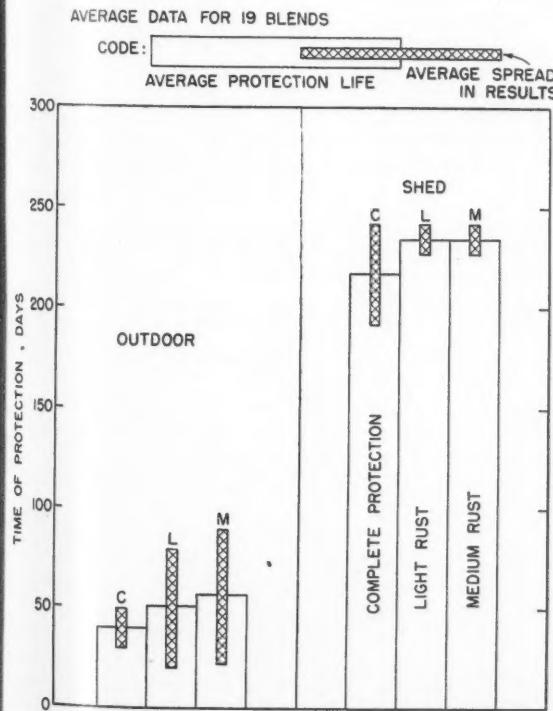


Figure 10—Comparative rust protective action of coatings in outdoor and shed exposure at Oakland. (C—Time of complete protection. L—Light rust. M—Medium rust.)

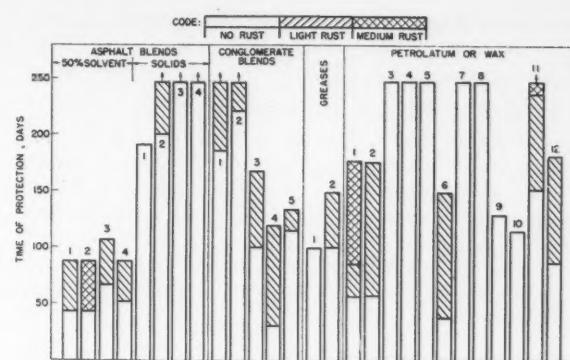


Figure 11—Effectiveness of better rust-preventive coatings in outdoor exposure tests at Oakland. (Tests started spring second year.)

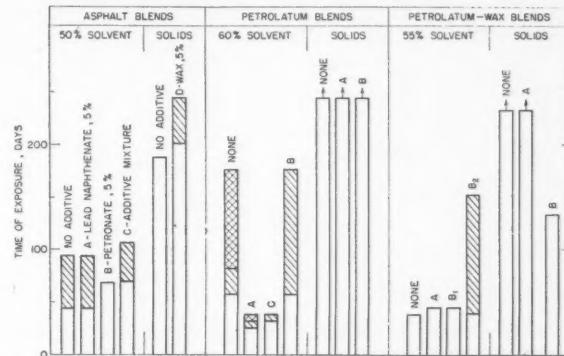


Figure 12—Effect of additives in protective action of rust-preventive coatings in outdoor exposure tests at Oakland.

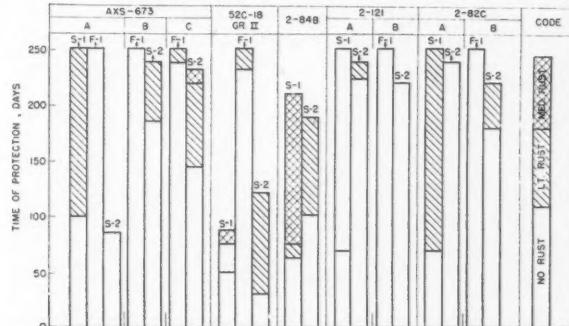


Figure 13—Effectiveness of commercial rust-preventive coatings in outdoor exposure tests at Oakland. (Code: S-1: Tests started spring first year; F-1: Fall first year; S-2: Spring second year.)

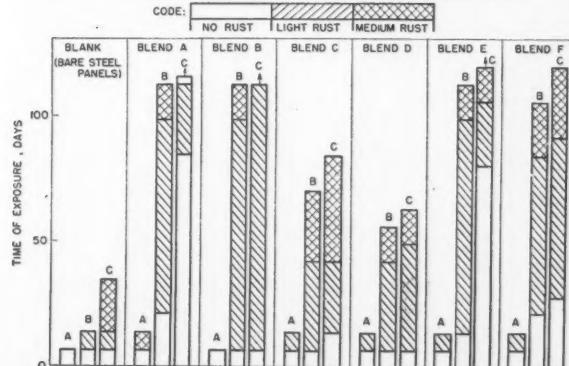


Figure 14—Effectiveness of rust-preventive films under varied conditions of field exposure at Oakland. (A—Outdoor rack. B—Conventional shed. C—Protected shed. Tests started in January.)

action than aged samples, possibly because of solution instability.

II. Rust-Preventive Films

a. Test Variables and General Observations. Petroleum-base rust-preventive films were tested primarily under conditions of intended usage, i.e., indoor (shed) exposure. Initial tests were made at Oakland, employing experimental products of variable laboratory behavior. Subsequent tests consisted of a study of oil or additive composition and concentration effects, application variables, and environmental effects.

It was noted that the protective action of rust-preventive films, unlike that of the coatings, was

extremely dependent upon the effects of atmospheric environment (cf. Figure 7). The effect of other variables was obscured or overshadowed in many instances.

The field tests were commenced in early summer. In the warm dry inland area, all products including base oils afforded "good" protection until the beginning of the rainy season, whereupon all products failed rapidly (in shed exposure). Thus, all products were rated "good" there being little spread between the best and worst products.

For field tests started simultaneously in the cool humid coastal area, the protective action of films was considerably less. Here, the better products afforded reasonably good over-all protection, but there was a

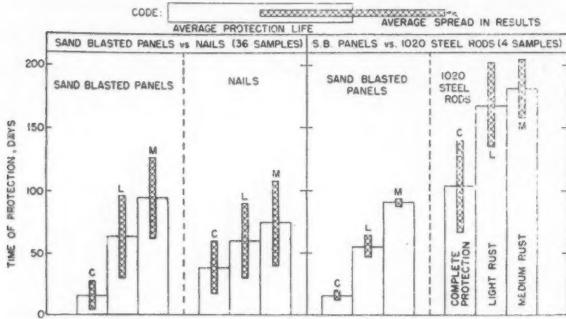


Figure 15—Comparative rust preventive action of films on various types of surfaces in shed exposure at Oakland. (C—Time of complete protection. L—Light rust. M—Medium rust.)

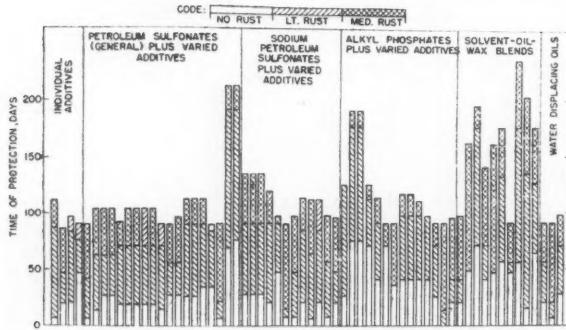


Figure 16—Effectiveness of better rust-preventive films in shed exposure tests at Oakland. Started in Spring of second year.

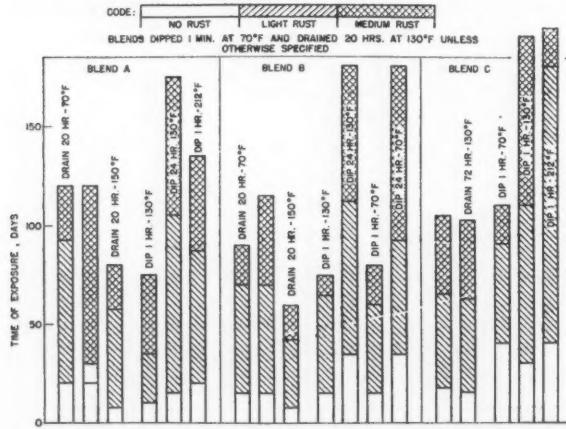


Figure 17—Influence of application variables on the effectiveness of rust-preventive films in shed exposure tests at Oakland.

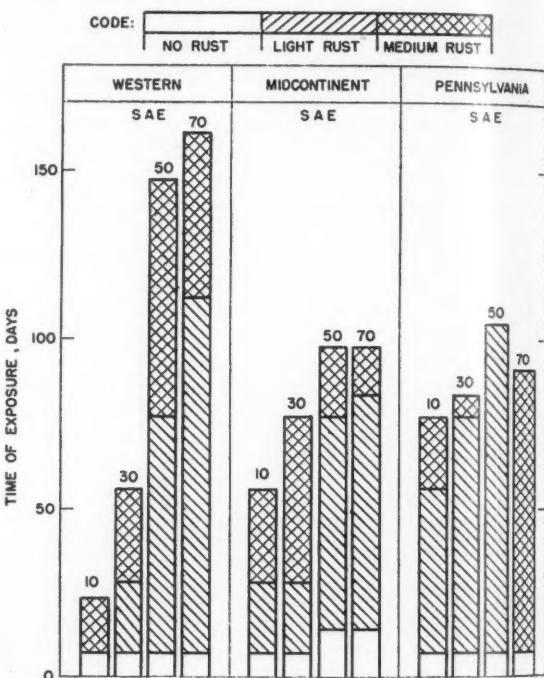


Figure 18—Effect of base oil composition and viscosity on rust-preventive films in shed exposure tests at Oakland. (Comparable additive blends.)

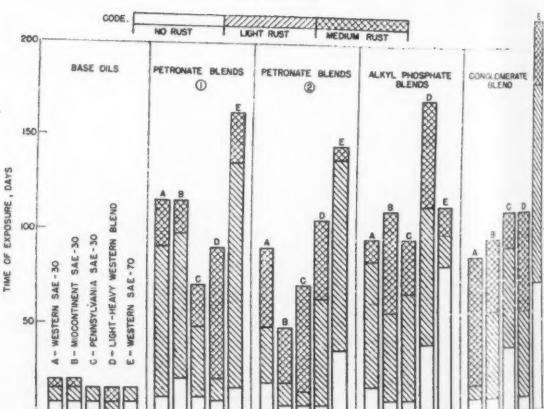


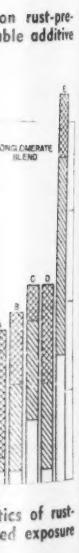
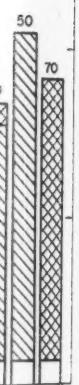
Figure 19—Effect of base oils on performance characteristics of rust-preventive films in presence and absence of additives. (Shed exposure tests at Oakland.)

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widespread difference in the behavior of the best and worst products. Again, with the beginning of the rainy season, all products failed rapidly, irrespective of their previous time in storage.

One cause of the accelerating effect of rain in either location was found to be the infiltration of rain (because of wind) into the shed. Subsequently, it was noted (Figure 14) that improved protection could be obtained even during the rainy season by use of sheltered shed storage, i.e., a shed wherein the louvers were baffled 75 percent to reduce air circulation; this protected method of exposure is also probably more indicative of intended usage.

Conversely, Figure 14 shows that petroleum-base rust-preventive films provide negligible protective action in direct outdoor exposure. These tests were initiated in winter but during a dry period. Corrosion was first observed and subsequently found more pronounced on the underside, possibly because of dew.

In coastal shed-exposure tests, films afforded equal protection on panels and nails (Figure 15) but somewhat greater protection on the special test rods, probably because of decreased drainage.

For all films, rusting occurred initially at random, indicating general film failure. Corrosion may have been initiated by dirt particles acting as hygroscopic centers,⁵ dew,⁶ or occasional water droplets entering the shed. The time of complete protection was represented by a small but variable portion of the "over-all" protection time in shed exposure. The measure of over-all protection time appeared to provide the most pertinent indication of product quality.

b. **Protective Action of Films.** In these tests, the effect of blend and application variables could be determined only for exposure under coastal conditions, and even here these effects were considered of secondary importance as compared with atmospheric influences. Discussion is therefore limited to results on films in coastal shed exposure.

The magnitude of protective action of the better rust-preventive films is shown in Figure 16. These provided "over-all" protection for periods up to six months and complete protection for several weeks.

Figure 17 shows that the extent of protection is dependent upon the method of application. Improved protection is generally attained by increasing the time or temperature of application (dipping) or decreasing the time or temperature of draining. Conventional application conditions are not the optimum from a rust-preventive standpoint. Occasional discrepancies in the above trends as shown are felt due to the extreme sensitivity of films to environmental influences.

Effects of base-oil composition and viscosity on rust-preventive action are shown in Figure 18. Heavier oils generally gave improved protection, possibly because of decreased drainage, but oil source was also important. Western Oils (100 percent distillate) were most sensitive to viscosity, light grades being inferior to Mid-Continent or Pennsylvania distillate—bring stock blends, while heavy grades were superior.

Similar and more detailed tests are shown in

Figure 19. Base oils, regardless of viscosity, provided little protective action. Oils in additive blends functioned in the manner described above and similar additive trends were noted for different oils. In general, oil composition and viscosity effects proved to be at least as important in controlling the quality of additive blends as were the additives themselves.

Additive-type effects³ have already been indicated in Figure 16; examples of detailed data are given in Table III. Most of the data were obtained with a typical base oil.

In general, additive-type effects were more important than concentration. In combinations, additive effects were not cumulative, but rather were indicative of the magnitude of protection to be expected from the more effective individual components. Differences in field results are much smaller than those noted in the laboratory.

Where lubrication is not required, films can be made from solids, heavy oils, and solvents as well as from oils plus additives. In many instances these products function like thin coatings and provide good protection (cf. Figure 16).

Under comparable conditions of test, films generally proved considerably inferior to coatings in rust-preventive action.

III. Control-Panel Tests

The effect of atmospheric influences on prolonged exposure tests is well known.^{7,8} Similar studies were made to determine short-term effects. Measurements were made of qualitative (visual) and quantitative rates of corrosion for control panels of clean mild steel. Outdoor exposure tests and shed exposure tests were conducted over weekly and monthly periods, respectively.

Normally, corrosion was excessive in one week of outdoor exposure at Oakland and was about one-fourth as rapid in shed exposure. Corrosion rates increased markedly for both types of exposure during rainy periods. Qualitative measurements indicated corrosion to be more rapid on polished panels, but quantitative measurements indicated the reverse to be true.

Control-panel corrosion rates were considerably lower at Modesto (inland) than at Oakland (coastal) during the warm months but were comparable during the cold damp season.

During one week of very warm weather at Oakland, with corresponding low humidity, negligible corrosion occurred. This indicated corrosion to be greater at higher humidity and lower if the exposure period includes a daily drying-out cycle, in agreement with earlier observations of others.⁹

Control-panel studies were found to provide useful information concerning the magnitude and variability of corrosivity at any location. For these tests at least, observations from control-panel studies paralleled film behavior more closely than coating behavior.^{7,9}

D. Correlation of Field and Laboratory Tests

The above discussion and interpretation of results pertain solely to field behavior. Similar data were obtained for a large number of laboratory tests. The

significance of laboratory measurements as criteria of field performance is discussed below.

Individual laboratory tests are known¹⁰ to incorporate only some of the factors which may cause rapid corrosion in practice. The degree of acceleration of laboratory tests varies markedly. Thus, the water drip test is completed in minutes, the static drop test in hours, while the humidity cabinet test requires days. Some laboratory tests are more indicative of outdoor exposure and others of shed exposure. For simplicity, the two types are discussed separately.

I. Outdoor Exposure vs. Laboratory Tests

It will be recalled (cf. Figure 7) that uniform field results were obtained for outdoor exposure tests in coastal and inland areas. Thus, all outdoor exposure data were employed in these correlations, which are given in Table IV and Figures 20 and 21 for both series.

The correlation between laboratory and field results is not precise. Some agreement was obtained between outdoor exposure and the salt spray test¹¹ and, to a lesser extent, the combined humidity cabinet-ultraviolet light exposure test. Other tests such as the water drip, static drop, and seawater immersion failed to discriminate. The humidity cabinet test was too insensitive.

In reference to the more pertinent tests, it is noted

that, because of low precision, severe laboratory requirements were necessary to weed out all field products rated unsatisfactory. For the first series of tests (Figure 20) a salt spray test of >20 days, or a combined salt spray test of >10 days plus humidity cabinet-ultraviolet light exposure of >15 days, met the arbitrary requirements of satisfactory field performance. The latter test alone was too insensitive regardless of test level.

Similar relations were noted for the second series of tests although, statistically, test levels differed slightly. The salt-spray test again provided satisfactory correlation. For this series, however, insufficient results were obtained with the humidity cabinet-ultraviolet test to permit consideration.

Although the correlations apply to both outdoor test sites, no attempt was made to set up a "standard" laboratory criterion of quality for reasons described earlier. However, the utility of the more pertinent tests as laboratory tools is indicated.

II. Shed-Exposure vs. Laboratory Tests

Since shed-exposure results are extremely dependent upon atmospheric influences, it is impossible to obtain a general agreement between them and laboratory tests. The following correlations are considered specific for the particular shed exposure tests at Oakland and it is estimated that they should approach the type of correlation to be expected in most coastal and industrial areas for comparable

TABLE III—Typical Shed Exposure Test Data on Rust-Preventive Films
All Blends Contain SAE-30 Grade Western Oil

ADDITIVE		LABORATORY TESTS					SHED EXPOSURE TESTS, TIME OF PROTECTION, DAYS					
		Humidity Cabinet Time, Days for		Water Drip, Min.	Static Drop Hours	Oakland			Modesto			
TYPE	Conc. Percent Water	Initial Rust	Heavy Rust			Com- plete	Light Rust	Overall	Com- plete	Light Rust	Overall	
Blank (Uncoated).....	.....	<1	<1	1	.....	<7	7	15	11	29	>29
Petroleum Sulfonates	A	1/5	1/1	1/1	10/21	3.5 spread spread	7/7	15/28	21/42	57	162	184
	B	1/2	2/7	10/26	11/17	2.5 spread spread	7/7	7/13	7/91	112	78	184
	C	1/3	2/21	1/41	6/9	>8	7/21	7/48	42/91	29	162	184
		5				>8						
Alkyl Phosphate (D).....	1/5	<1/3	1/20	>90/90	.....	21/48	84/77	98/91	92	194	197
Monooleate (E).....	1	2	6	7	1.8	7	15	21	92	184	184	
A Plus E.....	1.4	18	43	19	spread	21	91	119	92	184	213	
	2.5, 2.5	19	59	.....	.....	7	15	42	.....	.....	.....
	4.1	17	38	.....	.....	7	15	42	.....	.....	.....
C Plus E.....	1.4	19	39	9	spread	7	56	98	57	162	184	
B Plus E.....	1.1	12	42	14	>4	21	48	63	.....	.....	.....
	2.2	22	39	24	spread	28	63	105	.....	.....	.....
	1.3	5	34	.....	.....	7	15	48	.....	.....	.....
	3.1	7	53	10	.....	21	71	105	11	148	184
	3.4	11	66	23	>4	21	71	91	.....	.....	.....
A Plus C.....	3.3	31	47	9	.....	21	71	105	92	184	213
B Plus C.....	3.3	21	100	7	spread	21	71	105	.....	.....	.....
D Plus C.....	1.3	16	51	6	.....	35	84	91	92	184	247
D Plus A.....	1.1	9	23	11	.....	34	55	90	.....	.....	.....
	1.4	7	18	34	spread	41	97	118	92	184	247	
	5.1	5	41	60	.....	41	97	118	.....	.....	.....
D Plus B.....	1.1	9	25	11	>8	41	97	111	106	184	213	
D Plus E.....	1.1	3	5	32	4.6	70	111	125	.....	.....	.....
	1.4	5	36	>8	41	90	111	92	184	213	
	5.1	10	25	>60	70	91	90	
Blank (Base Oil).....	<1	<1	2	0.17	7	15	21	57	162	184	

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periods of test. No correlation is possible for the warm inland tests where field protection was consistently good.

The correlations described are given in Table V and Figures 22 and 23. No single laboratory test afforded a precise measure of field behavior. Three tests, the water drip, humidity cabinet and static

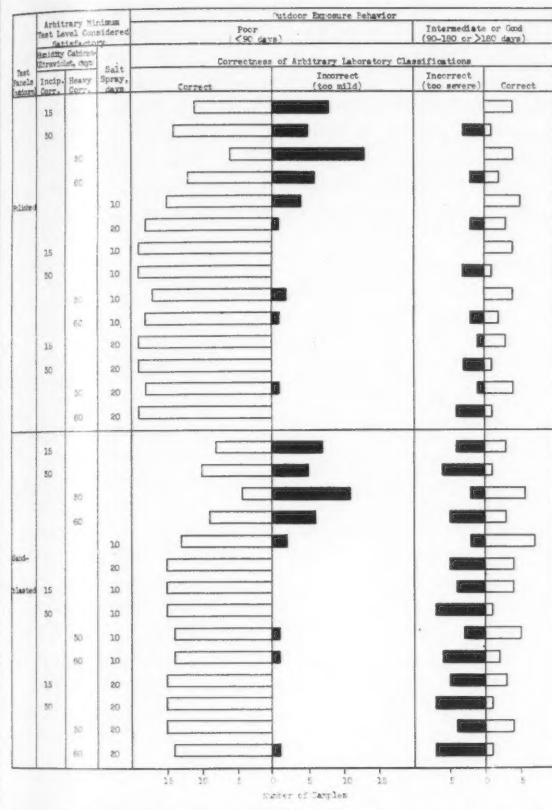


Figure 20—Correlation of individual and combined laboratory test results with outdoor exposure results for coating-type rust preventives at Oakland. Series A tests.

TABLE IV—Reliability of Laboratory Tests for Predicting Outdoor Exposure Performance of Rust Preventive Coatings

LABORATORY TEST		ARBITRARY TEST LEVELS CONSIDERED			CORRELATION WITH BEHAVIOR IN OUTDOOR EXPOSURE												
					OUTDOOR EXPOSURE BEHAVIOR				Polished Panels				Sandblasted Panels				
					Correctness of Laboratory [‡] Ratings		Poor	Intermediate	Good	All*	Poor	Intermediate	Good	All*			
Humidity Cabinet-Ultraviolet Light	Initial Corrosion Measurement	<15 Days	15-30 Days	> 30 Days	No. of samples rated	18	2	3	23	15	1	7	23				
					Correctness of Laboratory Ratings	Correct	10	1	1	12	8	1	1	10			
		<30 Days	30-60 Days	> 60 Days	High	8	..	..	8	7	..	..	7
					Low	..	1**	2**	3**	..	..	6**	6**		
					No. of samples rated	18	2	3	23	15	1	7	23				
	Over-all Corrosion Measurement				Correctness of Laboratory Ratings	Correct	5	..	1	6	4	..	2	6			
					High	13	1	..	14	11	..	..	11		
					Low	..	1**	2**	3**	..	1**	5**	6**				
	<10 Days	10-20 Days	> 20 Days	No. of samples rated	18	3	3	24	15	1	8	24					
				Correctness of Laboratory Ratings	Correct	14	2	3	19	13	..	4	17				
				High	4	..	..	4	2	..	..	2	
				Low	..	1**	..	1**	..	1**	4**	4**					

CODE: † Correct ratings—laboratory same as storage; high ratings—laboratory indicates greater protection than storage; low ratings—laboratory indicates less protection than storage. * Sum of Poor, Intermediate and Good. ** Safe, but insensitive ratings.

drop, correlated to some extent. The salt spray test results on films were consistently low, tending to substantiate their poor outdoor behavior (cf. Figure 15).

In the first series, the degree of correlation is shown for shed exposure with the better laboratory tests, together with the improvement in correlation attainable by simultaneous consideration of two or more laboratory methods. The water drip test (>25 minutes) afforded the best individual measure. Test requirements are rendered more severe but less sensitive by simultaneous consideration of the humidity cabinet test (>10 days) or static drop test (>3 hours) or both. The general insensitivity of the widely employed humidity cabinet test is noteworthy.

The second series (Figure 23) paralleled the above observations. In these tests, a water drip value of 15-20 minutes or a humidity cabinet life of 10-15 days correlated to some degree with shed exposure. Increasing either test level further, or considering both tests simultaneously, provided some assurance of weeding out unsatisfactory products but at the expense of eliminating a large number of products found satisfactory in the field.

These data indicated the difficulty of correlating

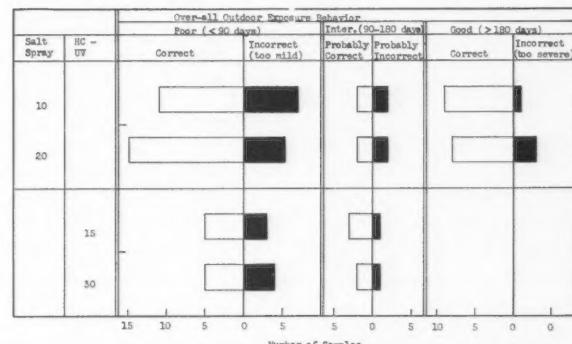


Figure 21—Correlation of laboratory tests results with outdoor exposure at Oakland. Series B tests.

shed exposure with field performance. From a control standpoint, laboratory tests are easier to reproduce and hence probably of greater utility. However, laboratory tests tend to exaggerate composition and application effects to a greater extent than is noted in the field. Likewise, observations from fundamental studies must be considered in the light of the leveling-off influence of Mother Nature where numerous factors are involved simultaneously.

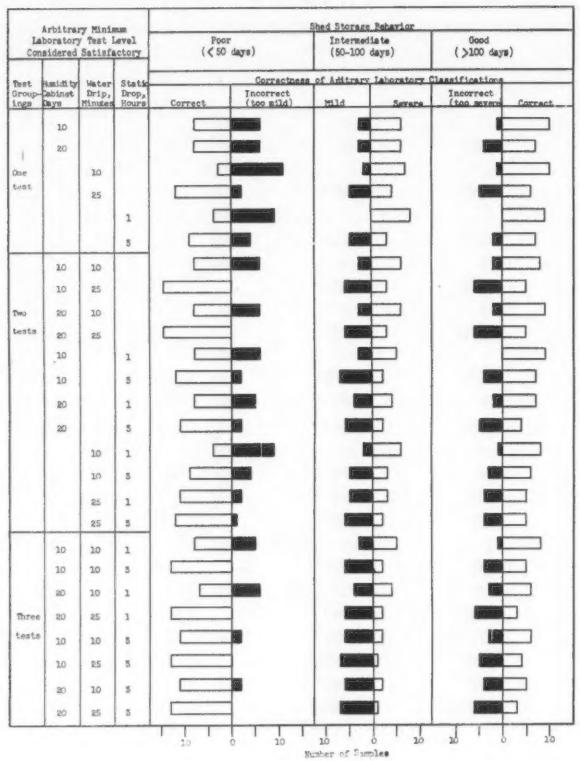


Figure 22—Correlation of individual and combined laboratory tests results with shed exposure results for film-type rust preventives at Oakland. Series A tests.

E. Résumé

The quality of petroleum-base rust preventives can be determined either on the basis of field or laboratory tests. A rough correlation exists between the two types of measurements. Studies of outdoor exposure tests have yielded considerable information concerning composition, application, and the influence of environment on protective action.

The behavior of petroleum-base rust-preventive films in shed exposure tests is strongly dependent upon atmospheric influences, thus precluding any simple correlation between field and laboratory results. Under controlled field conditions, effects of composition and application on quality are readily ascertainable, but these effects are usually less than noted in laboratory tests. Conventional shed-exposure tests rate petroleum-base rust-preventive films too severely.

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TABLE V—Reliability of Laboratory Tests for Predicting Shed Exposure Performance of Rust Preventive Films

LABORATORY TEST	ARBITRARY TEST LEVELS CONSIDERED			CORRELATION WITH BEHAVIOR IN SHED EXPOSURE				
	Poor	Intermediate	Good	SHED STORAGE BEHAVIOR				
				Correctness† of Laboratory Ratings	Poor (<50 Days)	Intermediate (50-100 Days)	Good (>100 Days)	
Humidity Cabinet	<10 Days	10-20 Days	>20 Days	No. of Samples	14	9	11	34
Water Drip	<10 Min.	10-25 Min.	>25 Min.	Correctness of Laboratory Ratings	Correct	8	0	7
				High	6	3	0	9
				Low**	0	6	4	10
Static Drop	<1 Hour	1-3 Hours	>3 Hours	No. of Samples	14	9	11	34
				Correctness of Laboratory Ratings	Correct	3	3	6
				High	11	4	0	15
				Low**	0	2	5	7
				No. of Samples	13	8	9	30
				Correctness of Laboratory Ratings	Correct	4	5	7
				High	9	3	0	12
				Low**	0	0	2	2

CODE: † Correct ratings—laboratory tests give comparable rating with field behavior; high ratings—laboratory tests indicate product to be better than from field observations; low ratings—laboratory tests indicate product to be inferior to field observations.

* Sum of Poor, Intermediate and Good.

** Safe, but insensitive ratings.

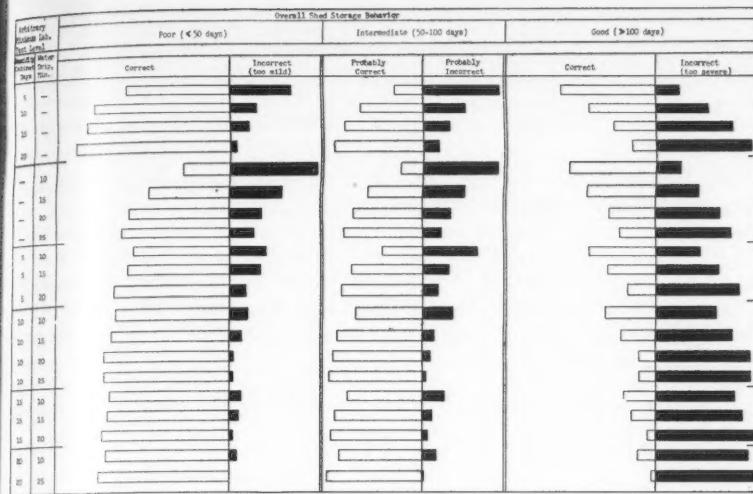


Figure 23—Correlation of individual and combined laboratory test results with shed exposure for rust-preventive films at Oakland. Series B tests.

DISCUSSION

Comments by P. J. Keating, Jr., The Texas Co., Technical and Research Division, New York, N. Y.:

It will be agreed, by anyone concerned with the development of rust preventives, that it would be highly desirable to establish correlation between field and laboratory evaluations. In the article above, the authors have reported considerable data resulting from controlled field and laboratory tests, and it is quite apparent that they have had some success in correlating the two types of data. It is noted, in particular, that a distinction has been made between two types of petroleum base rust-preventive material, namely, coatings and films. This distinction is believed to be highly important because the two types have specific application in industry, but it has been our experience that their evaluations must be made on entirely different bases.

The degree of successful correlation of field and laboratory evaluation obtained by the authors has not been obtained in our own laboratories. The reason for this situation is undoubtedly due to the fact that tests, such as humidity cabinet, humidity cabinet—ultraviolet light, salt spray, etc., were used to judge arbitrary performance levels, such as "poor," "intermediate" and "good," whereas the methods of test, when encountered in government specifications, do not permit such a consideration. Usually the tests specify that one panel shows no corrosion, whereas the second panel should show only a trace of corrosion which does not increase on fifty hours additional exposure when the humidity cabinet test is involved. In the case of the other two tests, no rusting is permitted. It has been our experience that the usual laboratory test methods for evaluating rust preventives are so poor from the standpoint of reproducibility between different laboratories that correlation of field performance with these tests is of little value.

In the case of outdoor exposures, as applied to petroleum base rust preventives of the coating types, the salt spray and humidity cabinet—ultraviolet light exposure tests have some significance, but for the final answer, we rely on actual exposure in all cases.

In the case of film type rust preventives, we have had a recent experience which causes us to place considerable reliance on the shed exposure test, since laboratory tests have been of no value whatsoever. For the particular case in mind, it was necessary to change the formulation of a product because of additive availability. The new product showed an exceptionally high humidity cabinet test, that is, of the order of 1000 hours, as compared with the old product which showed only a few hundred hours resistance to this test. Yet, after the new product had been tested under a variety of commercial applications, complaints were received that the product was unsatisfactory and inferior to the former product. As a result of this situation, a complete investigation was made involving the use of tests such as the following:

Special Performance

0.1% HBr. Acid Neutralization (USA 2-126)
 Fingerprint Removal (AXS 1719)
 Metal Corrosion, 8 Metals, 26 Days, 77° F. (Fed. Spec. 530.4)
 Synthetic Sea Water Immersion (USA 2-126)
 4% Salt Spray, Intermittent (Navy 52-C-16A)
 "Black Corrosion"—Two Special Tests

Humidity Resistance Tests

100° F. Humidity Cabinet (USA 2-126)
 100° F. Humidity Cabinet (8 Hr.); Room 77° F. (16 Hr.) Special Test
 0° F. (5 Hr.); 100° F. Humidity Cabinet (19 Hr.) Special Test

By none of these tests could the complaint on the new product be substantiated. As a matter of fact, the trend of the data was toward superiority. As we checked into this matter further, particularly commercial applications, it became clear that the shed exposure test could be used to show wide differences in the protection of various formulations, and it is expected that the test will be given considerable weight when selecting a final improved product.

Another property which seems to be of considerable importance is the fact that rustproofed articles in metal to metal contact are apt to develop a type of corrosion which we term "black corrosion." This is believed to be due to corrosion occurring under con-

ditions of deficient oxygen supply. Since this type of corrosion is apt to occur with articles packaged in paper boxes, it is believed that our test developed to evaluate this property will prove to be of considerable value.

In conclusion, it has been our experience that the usual types of laboratory tests encountered in specifications for rust-preventive materials have not been very helpful in predicting field performance.

Author's Reply:

In reply to comments from Mr. P. J. Keating, Jr., we agree that it is extremely difficult to correlate field exposure tests with conventional laboratory

tests, if the latter are interpreted in the usual manner, i.e., a go-no-go basis. That is why we used various gradations of rusting to indicate the relative degrees of protective action in both types of tests, and very likely why we noted a better degree of correlation between laboratory and field tests than others.

As for the use of shed exposure tests alone as a criterion of quality, this may have one drawback not realized by Mr. Keating. In our tests, different magnitudes of protective action were noted for tests started at different times due to seasonal and locational effects. Thus, such tests may afford a relative, but certainly not an absolute picture of product performance.

DISCUSSIONS

Discussion on "THE USE OF AMMONIA IN CONTROL OF VAPOR ZONE CORROSION OF STORAGE TANKS," by F. T. Gardner, A. T. Clothier and F. Coryell, CORROSION, 6, No. 2, 58-65 (1950) Feb.

Reply to Discussion¹ by D. A. Shock, by F. T. Gardner and A. T. Clothier:

The review of the ammonia paper presented by D. A. Shock, Continental Oil Co., was very thorough and was of considerable interest to the authors. There are, however, certain discrepancies between the statements by the reviewer and the text of the reference which he cited which should be pointed out.

The attached excepts from the paper, "Corrosion of Pressure Still Equipment," by G. Egloff and J. C. Morrell² contain all references which they made to the use of ammonia as an inhibitor. This paper was cited by the reviewer as proving that "... the use of ammonia in less than stoichiometric amounts to neutralize the hydrogen sulfide present in the gas over a steel surface receiving protection . . . has been recognized in refinery practice for a considerable time." This statement is not in agreement with the text of the cited reference which states, "The results so far indicate that corrosion is cut down 50 percent or more by the use of relatively small amounts of caustic soda solution³ compared with the quantities required to neutralize all of the hydrogen sulfide present in the gas." No reference to the use of ammonia in less than amounts required for formation of normal ammonium salts is made in the Egloff and Morrell paper. The fact that ammonia was not considered as an inhibitor for hydrogen sulfide corrosion is further shown by this additional statement taken from the reference: "The methods of attack in preventing corrosion from these two sources (HCl and H₂S) must of course be considered separately. In regard to the corrosion due to hydrochloric acid the problem is quite simple. Corrosion from this source occurs only in those parts of the system where condensation takes place, namely in the vapor lines from the dephlegmator and the condenser and receiver. Hence simple neutralization by alkaline solutions, preferably ammonium hydroxide or by ammonia will remedy this type of corrosion."

It is felt that the expanded discussion of the probable protection mechanism for ammonia in a gaseous hydrogen sulfide bearing system presented by Mr. Shock is in complete agreement with that proposed in the paper. The authors are indebted to the reviewer for his study and possible clarification of the process which was discussed only briefly in the presentation. His statement, "These pH values show that relatively small amounts of ammonia will more than neutralize the high concentration of hydrogen sulfide content of the gas," possibly should be given some additional clarification. It is presumed that he refers to pH values greater than 7. Field measurements made during the test showed pH values of water droplets condensed on the steel surface of untreated tanks to average about 6 while similar droplets in treated tanks had pH values averaging slightly over 7.

Except from Paper, "CORROSION OF PRESSURE STILL EQUIPMENT," by G. Egloff and J. C. Morrell.

"The methods of attack in preventing corrosion for these two sources (HCl and H₂S) must of course be considered separately. In regard to the corrosion due to hydrochloric acid the problem is quite simple. Corrosion from this source occurs only in those parts of the system where condensation takes place, namely in the vapor lines from the dephlegmator and the condenser and receiver. Hence simple neutralization by alkaline solutions, preferably ammonium hydroxide or by ammonia will remedy this type of corrosion."

"To overcome corrosion in pressure still equipment various chemicals have been used. These consist mainly of the alkalies such as solutions of sodium hydroxide, ammonium hydroxide and suspensions of lime. These correctives are usually injected into the dephlegmator and beneficial results have been obtained from their use . . .

"The results so far indicate that corrosion is cut down 50% or more by the use of relatively small amounts of caustic soda solution compared with the quantities required to neutralize all of the hydrogen sulphide present in the gas. Calculations show that less than 10% of the amount of caustic necessary to neutralize the hydrogen sulphide will give the above result. The use of caustic soda is now a commercial means of cutting down corrosion."

"Ammonia is used in relatively small amounts, due to its cost. Further the ammonium sulphide formed is unstable in the hotter portions of the system. Ammonia is used principally for the neutralization of hydrochloric acid. The manner of introducing it is similar to that of caustic soda."

1. D. A. Shock, *Corrosion* 6, 64-5 (1950) Feb.

2. G. Egloff and J. C. Morrell, *AIME, Petroleum Development and Technology*, 1926, 571-579.

3. The parenthetical expression and italics in the quoted text have been added by the authors.

Polarographic Study of Corrosion Phenomena*

I. Introduction—Experimental Technique—Analysis and Interpretation of Polarograms

By PIERRE VAN RYSELBERGHE,¹ JOHN M. MCGEE,² ARMIN H. GROPP,³
ROBERT D. WILLIAMS⁴ and PAUL DELAHAY⁵

Introduction

AS FAR as we have been able to ascertain, the idea of using the polarograph as a tool in the study of corrosion phenomena had never been advanced at the time our group at the University of Oregon proposed it to the Office of Naval Research. Our search of the literature was made in the field of polarography itself rather than in the immense field of corrosion because a number of good, nearly up-to-date bibliographies of polarography are available in which both theoretical and applied papers are listed (Ref. 1). Final check of the literature through Chemical Abstracts likewise gave no indication of any previous polarographic studies of corrosion processes.*

To anyone familiar with the principles of polarography and with at least some of its outstanding applications the possibilities of the method in the study of corrosion should be quite obvious. Let us first define the types of corrosion which come within the scope of a polarographic approach:

The corroding materials include, in principle, all metals and alloys.

The corrosive media are aqueous solutions of salts, acids or bases containing in addition oxygen (pure or dissolved as air), carbon dioxide (pure or again dissolved as a component of air), any arbitrary mixtures of oxygen and carbon dioxide, various substances which, either from the theoretical or the practical point of view, may be expected to play a part in corrosion, such as small amounts of hydrogen peroxide (a possible intermediate in the reduction of oxygen), protective substances such as chromates, etc.

The polarograph is an instrument which records reduction currents resulting from the application of gradually increasing cathodic potentials to a dropping mercury electrode. Our application of the method to corrosion is based upon the fundamental idea that

consumption of such compounds as oxygen, carbon dioxide, hydrogen peroxide, hydrogen ion, etc., by metallic surfaces dipping in electrolytic solutions containing these compounds can be followed through the variation with time of their polarographic reduction currents. In this manner very sensitive and very rapid corrosion tests can be carried out, thanks to the remarkable sensitivity of the polarograph to minute changes of concentrations of reducible substances. In some cases the corrosion process includes the dissolution of some of the metal as aqueous ions and these ions will themselves undergo polarographic reduction. In our work the emphasis is, however, on the consumption of oxygen, carbon dioxide, etc., by the metal rather than on the dissolution process of the latter.

The most important substance in corrosion by aqueous media is oxygen, whose role as a "cathodic depolarizer" in the local galvanic couples formed on metallic surfaces is discussed at length in the literature of corrosion. It also can play a protective role through formation of oxide films. Consumption of oxygen is therefore one of the main processes one should follow in quantitative corrosion studies. The polarograph furnishes an ideal method of following oxygen concentration changes, thanks to the well-established two-step reduction: O_2 to H_2O_2 , H_2O_2 to H_2O . In our work a considerable amount of time was spent in calibration work (comparison between polarographic and ordinary analytical determinations of oxygen, variation of reduction potentials with composition of the solution, etc.) before actual oxygen consumption studies with metals were undertaken. In the same manner considerable preliminary work had to be carried out with carbon dioxide. The polarographic reduction of carbon dioxide was first detected and studied in our Laboratory (Ref. 2). In mixtures of oxygen and carbon dioxide and in mixtures of hydrogen peroxide and carbon dioxide the very interesting formation and subsequent polarographic reduction of percarbonic acid were also first observed in this Laboratory. Our corrosion studies have included so far:

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* A brief reference to the possible use of the polarograph in corrosion research is to be found in "Protective Coatings for Metals," by R. M. Burns and A. E. Schuh. (Reinhold Publish. Corp., New York, 1939. See p. 272.) It is suggested by these authors that the formation of a soluble ion from a metal such as lead could be followed polarographically. Our fundamental idea is to follow the corrosion process from the other end, namely through the variation of oxygen concentration, although the formation of a soluble ion can also be followed whenever a reduction wave for this ion is detectable.

(Note: Matter within brackets above and elsewhere in this article is material not part of the original article.)

determinations of consumption of oxygen by pure metals and alloys;

determinations of consumption of carbon dioxide by metals and alloys;

determinations of consumption of hydrogen peroxide by metals and alloys;

determinations of simultaneous consumption of oxygen and carbon dioxide and of hydrogen peroxide and carbon dioxide by metals and alloys;

investigations on a possible role of hydrogen peroxide in corrosion;

investigations on a possible role of percarbonic acid in corrosion.

Consumption of hydrogen ion by metals, i.e., corrosion by acids is also being studied. Corrosion by electrolyte solutions entirely deprived of oxygen and carbon dioxide has been studied to a certain extent through the appearance of metallic ions of the corroded metal.

The interest of the group at the University of Oregon is primarily towards the fundamental physical chemistry of corrosion rather than towards technical and practical studies of the many-sided aspects of corrosion. The observations on metals and alloys described in the present report should be regarded as examples among innumerable possible cases, types of conditions, etc., which could be studied with great convenience by the polarographic method.

General presentations of polarography are available in the books and papers listed under Ref. 3.

Experimental Technique

Polarographs:

In our work we have used two polarographs: a Sargent Polarograph Model XII of the Heyrovsky type with photographic recording, and a manual polarograph assembled from standard physical chemical equipment. Detailed descriptions of the former are available in the various brochures of the Sargent Company, in the book by Kolthoff and Lingane (Ref. 3), etc. The latter is a direct application of the fundamental principles of polarography as is shown in Figure 1, which gives the wiring diagram used in our work. The respective advantages and disadvantages of the photographic and of the manual recording methods will not be gone into in detail in the present report. From the point of view of applications to corrosion tests there are distinct advantages in the quick recording method afforded by the photographic instrument (or for that matter by any self-recording device), while from the point of view of detailed theoretical studies the manual method is often preferable, provided, however, the successive current-potential readings are sufficiently close to one another. Our discovery of the formation and subsequent reduction of percarbonic acid would easily have been missed if we had taken our readings at too large intervals. After having detected this phenomenon by the manual method we easily found it also by the photographic method, where the usually very small steps of the percarbonic acid reduction has been missed before. We are convinced that previous workers actually had

evidence for this phenomenon on their polarograms but missed observing it because their curves recorded by the manual method were based on experimental points too far distant from one another. In the selection of a commercial polarograph the discussion by Lingane (Ref. 4) will be found useful.

Polarographic Cells:

We have used two types of cells: the small Erlenmeyer cells provided with the Sargent polarograph for experiments which did not involve metallic samples, and cells of constant cross-section for experiments on metallic samples. This latter type of cell is represented on Figure 2.

The metallic samples, usually close to 4.5×2.5 square centimeters in area, and between 0.02 to 0.31 centimeter in thickness were held vertically in the cell through a groove cut in a glass ring resting on the bottom of the cell without any contact of the metal with the mercury of the anode. The drops of mercury falling from the capillary tube move in a stream parallel to the metallic sample and cause enough stirring to maintain the solution practically homogenous with respect to the constituents involved in the corrosion process. We have verified this point in two ways:

1. Gentle shaking of the whole cell causes no change in oxygen concentration as detected by the polarograph after a certain amount of oxygen consumption by the metal has taken place.

2. Measurements of oxygen consumption rates on samples of different areas indicate that the ratio of rate to area is constant for a given oxygen concentration. This could not be the case if the oxygen concentrations determined through reduction at the mercury cathode were not the bulk oxygen concentrations in the solution, which are also the effective oxygen concentrations for the corrosion process at the metal surface. We have verified this point with three samples of zinc dipping in 0.1 normal tetramethylammonium bromide.

It should be noted that in our experiments, as car-

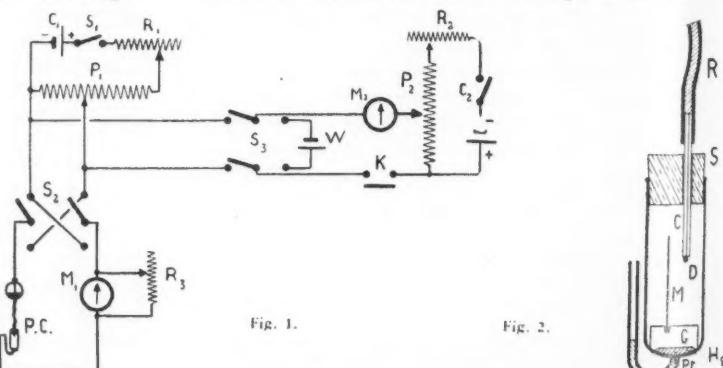


Figure 1—Circuit of Manual Polarograph. (C₁) Battery of polarographic circuit, (C₂) Battery of measuring potentiometer, (K) Tap key, (M₁) Galvanometer of polarographic circuit, (M₂) Galvanometer of potentiometer circuit, (P₁) Slidewire to apply variable potentials to polarographic cell, (P₂) Potentiometer slidewire, (P.C.) Polarographic cell, (R₁, R₂) Variable rheostats, (S₁, S₂, S₃) Switches, (W) Standard cell.

Figure 2—Polarographic Cell used for Corrosion Tests. (R) Rubber tube connected to mercury supply, (S) Rubber stopper, (C) Capillary tube (Corning marine barometer tubing), (D) Dropping mercury electrode, (M) Metallic sample, (G) Glass ring, (Hg) Mercury anode, (Pt) Platinum contact.

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ried out so far, the corroding metal has no electrical connection with the polarographic circuit. The metal is not submitted to any cathodic or anodic polarization. The metallic samples are thus in a state very close to that of actual metallic objects in the natural conditions in which they may be used. Studies involving application of controlled potentials to the samples while in contact with corroding solutions are being undertaken at the present time.

Solutions of Supporting Electrolytes:

In general 0.1 normal solutions of C.P. salts were used as supporting electrolytes. Some exploratory experiments were carried out with sea water. The following pure salts have been used:

Lithium and potassium nitrates (advantage: the anion is not oxidizable on the anodic side of the potentials applied to the dropping mercury electrode, a fact permitting a better definition of the zero point of the first oxygen wave and of its lower tangent);

Lithium and potassium chlorides (these salts give a fairly good definition of the zero point and lower tangent of the first oxygen wave);

Potassium bromide (the bromide ion is oxidizable and the zero point of the first oxygen wave is not well defined);

Magnesium chloride, sulfate, perchlorate (the magnesium ion has a rather high polarographic reduction potential and permits the detection of the carbon dioxide wave; the perchlorate presents the interesting advantage of having a residual current practically equal to zero);

Tetramethylammonium bromide and chloride, tetraethylammonium bromide (the very high reduction potentials of the quaternary ammonium ions permit the detection of the carbon dioxide waves. These salts were always carefully recrystallized several times from hot water-alcohol mixtures).

These solutions of supporting electrolytes were saturated with air for experiments on oxygen consumption; deprived of air in toto or in part, with variable amounts of carbon dioxide added, for experiments on carbon dioxide consumption and on simultaneous oxygen-carbon dioxide consumption.

Chemical Determination of Oxygen and Carbon Dioxide:

Our chemical determinations of dissolved oxygen were carried out by the classical Winkler method (Ref. 5). Once the polarographic waves of oxygen have been calibrated in a particular supporting electrolyte and for given characteristics of the capillary, drop time of the mercury, etc., no further chemical determination is necessary since the height of the first oxygen wave is proportional to the concentration. In most of the solutions used in our work the solubility of oxygen in air-saturated solutions was close to 10 milligrams per liter at a room temperature close to 25° C.

For carbon dioxide a measured volume (usually 50 ml.) of the solution is run into an excess of 0.1 normal barium hydroxide solution in an enclosed

beaker fitted with suitable connections for mixing, the solutions by stirring with carbon dioxide-free nitrogen or air. The uncombined Ba(OH)₂ should then be determined by titration with 0.1 normal HCl using thymol phthalein or phenol phthalein as indicator. Obviously any aqueous solution which contains a buffer or other substance reacting with the Ba(OH)₂ cannot be titrated in this way and a more time-consuming method such as that of Petterson or of Lunge and Marchlewski (Ref. 6) must be used. Since many of our samples were supersaturated solutions of carbon dioxide the introduction into the barium hydroxide solution had to be made quickly and with a minimum of agitation or aeration. The Ba(OH)₂ solution must be protected from exposure to CO₂ of the air and all mixing, agitation of solutions, and washing of the titration apparatus must be done in an atmosphere free of CO₂ and with water which is also free of CO₂.

Recording of the Polarograms:

The photographic records obtained with the Sargent instrument are on large sheets of photographic paper of 10" \times 6" allowing very convenient geometrical analysis. Depending on the range of potentials recorded, from one to four sets of curves can be registered on the same sheet of paper through the convenient shift of the initial position of the zero potential afforded by the Sargent instrument.

With the manual polarograph the polarograms are plotted on as large a scale as possible on graph paper. The variations of O₂ and CO₂ concentrations caused by corrosion processes appear in a very striking manner on these plots. The quantitative data are obtained in the manner outlined in the next section of this paper.

From the practical point of view the use of the polarograph in corrosion studies does not require complete curves. A few adequately chosen readings will give most of the useful information. The selection of the useful potentials is discussed further in this report. The method of using these selected potentials has been applied in the design of a portable polarograph by one of us (P. D.). This portable polarograph will be described in another communication. Besides its use in corrosion work such an instrument would be of great value in water pollution studies since oxygen determinations could be carried out on the spot without the necessity of removal of the samples to the laboratory and the danger of errors due to the possible reentry of air.

Analysis and Interpretation of Polarograms

Polarograms of Oxygen.

The literature on the polarographic reduction of oxygen is quite extensive. The two-step reduction of oxygen at the dropping mercury cathode was first reported by Heyrovsky in 1924 (Ref. 7). From our point of view the two most important papers are those of Kolthoff and Miller (Ref. 8) and of Petering and Daniels (Ref. 9). A good summary is available in the book by Kolthoff and Lingane (Ref. 10). The

possibility of determining small amounts of oxygen and the variation with time of oxygen concentration has been applied by physiologists in a type of micro-Warburg method. A detailed description of this method is available, for instance, in a laboratory manual by Umbreit, Burris and Stauffer (Ref. 11). In our early work we began by using the Petering-Daniels method which is based upon the uniform use of the applied potentials 0.1 and 1.0 volt between the dropping mercury cathode and either a mercury pool serving as anode or a saturated KCl—calomel electrode located in a separate vessel connected with the polarographic cell by means of a salt bridge. Some of our work was also carried out with a separate calomel electrode but this introduces a number of complications, in particular the very high ohmic resistance thereby added to the circuit. We soon recognized that the Petering-Daniels method is oversimplified. The first half-wave potential for O_2 reduction, i.e. that of the reduction to H_2O_2 , is close to 0.1 volt v. the saturated calomel electrode, but varies enough with the nature of the medium, the pH, etc., to make the constant potential of 0.1 volt in general an undefined point of the wave. The same situation holds for the potential of 0.1 volt, which is in the neighborhood of the second half-wave potential for O_2 reduction, i.e. that of the reduction for H_2O , but is not in general exactly that potential. Between the two waves there is a rise of the residual current with a slope which also varies from one medium to another. The increase of polarographic current between 0.1 volt and 1.0 volt is thus a poorly defined composite function of the two reduction steps. Only is one were always to use the same electrolyte solution at the same controlled pH could the method be used. The presence of CO_2 , even in very small quantities, causes further complications which will be discussed later. This circumstance makes the method particularly unreliable as a micro-Warburg, which was precisely the main application for which it was devised. The ordinate AB on Figure 3 would, in the Petering-Daniels method, be a measure of O_2 concentration. In the presence of CO_2 the intermediate step shown on Figure 4 appears. It is due to the formation and reduction of percarbonic acid and it makes the significance of the AB oxygen current still more uncertain.

A correct determination of O_2 concentration should be based upon the properties of one or the other of the two waves. When the supporting electrolyte has an anion which can undergo anodic oxidation, the bromide ion for instance, the zero point of the first

wave and its lower tangent are poorly defined. On the other hand the lower and upper tangents of the second wave are usually well-defined and, in most cases, nearly parallel. In the case of bromides and chlorides used as supporting electrolytes the potential interval 0.75 to 1.25 volt with respect to practically any of the ordinary anodes, including pure mercury in contact with the 0.1 normal supporting electrolyte, will encompass the whole second wave. The nearly parallel tangents are at a practically constant vertical distance from each other, which is thus equal to the diffusion current i_d . The difference $i_{1.25} - i_{0.75}$ minus the correction MN of Figure 5 is equal to i_d . This correction MN could be estimated from the residual current for a blank solution entirely exempt of O_2 .

In solutions entirely free of hydrogen peroxide in bulk concentration and entirely free of CO_2 the first O_2 diffusion current should be equal or very nearly equal to the second one. If the zero of the first wave is not well defined the half-wave potential can nevertheless be determined by taking CD equal to AB/2. A true zero point F can thus be determined by taking DE equal to CD and drawing EF parallel to CM. With a nitrate used as supporting electrolyte, and usually also with a chloride, the lower tangent for the first wave is well-defined. The half-wave potential and the diffusion current can then be determined directly on this first wave as is shown on Figure 6.

When there is CO_2 present, as is the case whenever the solution is saturated with air, the height CD of the percarbonic acid wave of Figure 7 is to be added to the height EF of the H_2O_2 wave. One has then AB equal to the sum of CD and EF.

An important observation, whose implications from the point of view of corrosion will be discussed later, is that the presence of certain metals in air-saturated solutions of electrolytes causes the appearance of a certain amount of free H_2O_2 detected through the fact that the sum of CD and EF of Figure 7 becomes greater than AB. This polarographic detection of the formation of H_2O_2 during the corrosion process of these metals has been confirmed in several cases by the microchemical tests described below. Just as at the dropping mercury cathode O_2 is first reduced to H_2O_2 the cathodic consumption of O_2 in the local galvanic couples at the surface of the corroding metal may thus involve some incomplete reduction of H_2O_2 rather than complete reduction to water. The possibility of the formation of H_2O_2 during corrosion makes it all the more important to base the determination of oxygen and its consumption with time

upon the properties of the first wave. We recommend, therefore, that, in corrosion studies with polarographic cells containing a sample of metal, a supporting electrolyte such as KNO_3 or KCl be used in order to be able to determine oxygen concentrations from the properties of the first reduction wave. The possible formation of H_2O_2 is then indicated by the sum of CD and EF (Figure 7) being

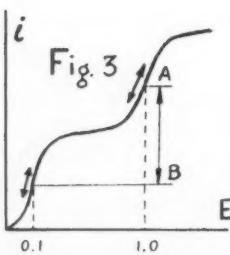


Figure 3—(without any CO_2).

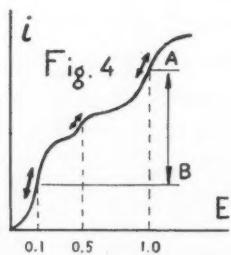


Figure 4—(with CO_2).

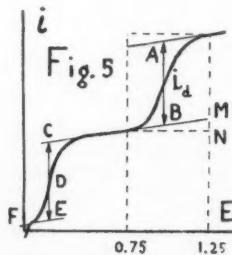
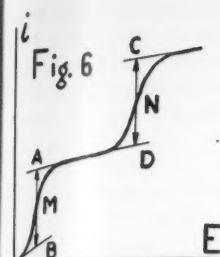
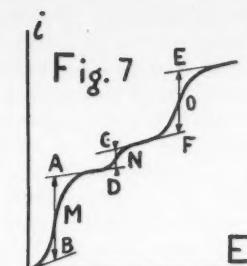


Figure 5—(with CO_2).

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Figure 6—(no CO₂).Figure 7—(CO₂ present).

greater than AB. Before concluding that the difference is really due to the formation of H₂O₂ one must ascertain that no reduction of metallic ions has taken place between the two reduction waves of O₂ and H₂O₂.

In the foregoing discussion it has been taken for granted that the troublesome maximum of the first oxygen wave has been suppressed through the addition to the solution of a drop of methyl red. Considerable discussion concerning this maximum is to be found in the literature.

Our calibration of oxygen reduction curves by means of Winkler determinations led to results in substantial agreement with the Kolthoff-Miller (Ref. 8) value for the proportionality between the first diffusion current of O₂ and the concentration of O₂ in millimoles per liter.

$$i_d = 15.5 \times C_o \text{ microamperes}$$

at 25 degrees C in 0.1 normal KNO₃, and for a capillary having characteristics such that the m^{2/3}t^{1/6} factor of the Ilkovic equation is 2.5. With other electrolytes this proportionality constant will vary somewhat, but a sufficiently accurate value of the constant can be obtained in each case from the diffusion current corresponding to saturation with air. In most 0.1 normal electrolytes saturated with air at 20-25 degrees C the amount of dissolved oxygen is, for all practical purposes, 10 milligrams per liter, making C_o 0.31 millimoles per liter.

In our manual polarograph oxygen currents were read with a galvanometer (Weston) having a resistance of 143.6 ohms, a sensitivity of 0.25 microampere per division, and usually shunted with a resistance of 500 ohms. This resistance gave convenient readings and provided at the same time an adequate amount of damping, the oscillations of the galvanometer needle being small and easy to take into account in establishing the average current corresponding to each applied potential.

With our usual shunt the reduction current is connected with the reading, N in divisions of the galvanometer by the formula $i = N$ microamperes. With the Sargent polarograph a number of shunts are available and the reduction current is obtained by the relation

$$i = 0.0032 \times N \times S \text{ microamperes}$$

in which N is the number of millimeters on the galvanometer scale (and also the number of millimeters along the axis of ordinates on the photographic pa-

per) and S is the sensitivity. For instance, with the very frequently used sensitivity 100 we have

$$i = 0.32 \times \text{microamperes}$$

a relation between current and galvanometer reading practically identical with that of the manual polarograph.

Polarographic Waves of Percarbonic Acid.

When we began to take polarograms of mixtures of O₂ and CO₂ a curious phenomenon came to light at once: the CO₂ caused an apparent shift of a portion of the H₂O₂ wave of O₂ towards smaller cathodic potentials. In solutions of tetramethylammonium bromide the shift was complete when the CO₂ concentration had reached a value practically equimolar with that of O₂. The displaced wave would then be an extension of the first O₂ wave with nothing more than an angle between the two waves, no flat diffusion current being noticeable any more between the first O₂ wave and this new wave. With LiCl, KCl, KBr this displacement was also occurring, but never became complete however large the concentration of CO₂ might be. It was then observed that CO₂ had the same effect on the H₂O₂ waves obtained when H₂O₂ was actually present in the original solution and not formed only at the dropping mercury cathode during the first reduction of O₂. It was found that this effect was due to the formation and subsequent reduction of percarbonic acid. This was confirmed by the fact that a Kahlbaum potassium percarbonate available in our laboratory gave reduction waves similar with those observed in O₂-CO₂ and in H₂O₂-CO₂ mixtures. Several preparations of potassium percarbonate were made and they all gave the same type of waves. An important observation was that, with H₂O₂-CO₂ mixtures, the percarbonate wave increases with CO₂ concentration but is never larger than the original H₂O₂ wave corresponding to the absence of CO₂. Detailed determinations of the relationship between CO₂ concentration and the height of this percarbonate wave were undertaken with solutions for which both the O₂ and CO₂ contents had been determined chemically. An apparent number of electrons n consumed per molecule of CO₂ reduced under the form of percarbonic acid was computed by the formula

$$\frac{i_{CO_2}}{i_{O_2}} = \frac{n}{2} \times \frac{D_{CO_2}^{1/2}}{D_{O_2}^{1/2}} \times \frac{C_{CO_2}}{C_{O_2}}$$

in which the i's and the C's are experimental quantities, the D's are the diffusion coefficients. The values of n so obtained increased rapidly from values much smaller than one as the CO₂ content decreased indicating that at the higher concentrations only a fraction of the CO₂ present is involved in the formation of percarbonic acid, while at the lower concentrations the CO₂ present is involved several times in the formation and subsequent reduction of percarbonic acid. Since this acid is formed at the surface of the mercury cathode as H₂O₂ is produced by reduction of O₂ and, since the acid then undergoes reduction at potentials intermediate between those of O₂

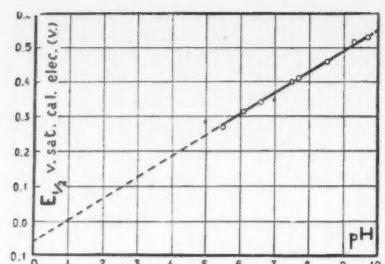


Figure 8—Variation of the half-wave potential of percarbonic acid with pH.

reduction to H_2O_2 and of O_2 reduction to H_2O_2 , there must be a time dependence of the magnitude of the percarbonic acid diffusion current. In particular there should be a decrease of current when the drop time of the mercury decreases. This is indeed the case as is shown by the following results obtained with an air saturated solution buffered at a pH of 8.5; for four different values of the drop time we found that the ratio of the height of the percarbonic acid wave to that of the first oxygen wave varied as follows:

Drop time seconds	Ratio percarbonic to oxygen
3.05	0.24
1.84	0.23
1.04	0.22
0.54	0.21

It should be noted that in an air saturated solution the amounts of O_2 and CO_2 are, respectively, about 10 and 0.4 milligrams per liter.

Besides our study of the percarbonic acid wave as obtained from air saturated solutions we took a large number of polarograms with solutions in which the percarbonic acid had been formed by reaction between bicarbonate ion and H_2O_2 . The composition of such solutions is much easier to control than that of mixtures of CO_2 and H_2O_2 in which one attempts to increase the concentration of percarbonic acid by

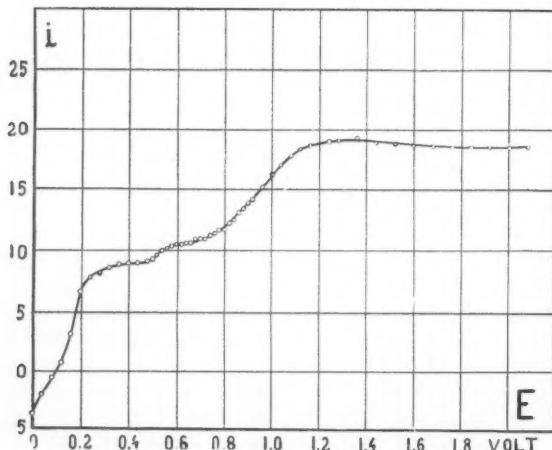


Figure 9—Polarogram of $O_2 + CO_2$
KCl 0.1N Sens: 1 div. = 0.322×10^{-6} A
 O_2 : 9.3 Mg./L Anode: Hg
 CO_2 : 1.6 Mg./L

dissolving CO_2 appreciably beyond its equilibrium concentration at saturation with air. Polarograms of such solutions maintained at various constant pH's by means of buffers led to the following dependence of the half-wave potential of percarbonic acid on pH, at 20°C,

$$E = -0.06 + 0.058 \text{ pH volt}$$

(See Fig. 8)

referred to the saturated calomel electrode. In this formula a positive value of E corresponds to a cathodic potential for the dropping mercury, a negative value to an anodic potential. It is a remarkable fact that the half-wave potential for this reduction varies linearly with pH, while the half-wave potentials for O_2 and H_2O_2 reduction do not vary with pH (Ref. 8). Kolthoff and other authorities in the field of polarography characterize the O_2 and H_2O_2 waves as irreversible and would consider that of percarbonic acid as reversible. A detailed discussion of the polarographic waves of percarbonic acid will be presented elsewhere.

It is interesting to note that percarbonic acid is appreciably stronger than carbonic acid. Electrometric titration curves gave, at 0°C, 2.5×10^{-6} and 2.5×10^{-7} for the two successive ionization constants.

Selection of Fixed Potentials for Oxygen Percarbonate Acid and Hydrogen Peroxide Determinations.

On the basis of the foregoing discussion and after examination of numerous complete polarograms we are able to suggest as fixed potentials for the determination of oxygen, percarbonic acid, and hydrogen peroxide those given in Table I below. The difference between the currents corresponding to V_2 and V_1 gives the oxygen concentration, the difference be-

TABLE I
Fixed Potentials for Oxygen and Hydrogen Peroxide Determinations

Electrolyte	V_1	V_2	V_3	V_4
Potassium chloride 0.1 N	0.06	0.52	0.72	1.48
Potassium nitrate 0.1 N	0.10	0.76	0.96	1.70
Tetraethylammonium bromide, 0.1 N	0.04	0.36	0.58	1.28
Sea water	0.00	0.40	0.62	1.30

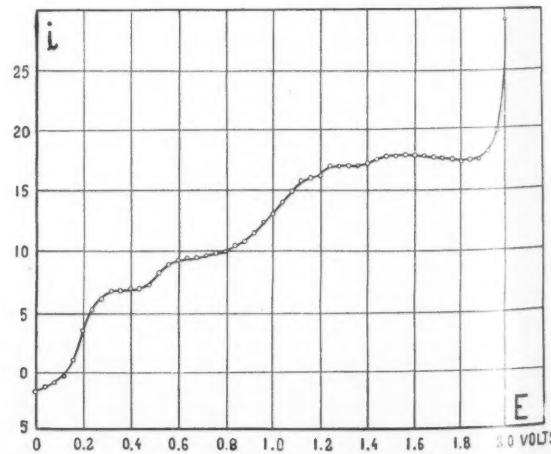


Figure 10—Polarogram of $O_2 + CO_2$
KNO₃ 0.1N Sens: 1 div. = 0.322×10^{-6} A
 O_2 : 9.5 Mg./L Anode: Hg
 CO_2 : 0.7 Mg./L

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V ₃	V ₄
0.72	1.48
0.96	1.70
0.58	1.28
0.62	1.30

tween the currents corresponding to V₃ and V₂ gives a portion of the hydrogen peroxide concentration measured as percarbonic acid, the difference between the currents corresponding to V₄ and V₃ gives the balance of the hydrogen peroxide concentration. In the absence of any bulk concentration of H₂O₂ the sum of the last two currents should be practically equal to the first current, while in the case of the presence of some H₂O₂ in bulk concentration the sum of the two last currents will be greater than the first current.

All these potentials are referred to a mercury anode covered with the supporting electrolyte indicated in the Table. Those potentials are in volts. The four cases presented in Table I are illustrated on Figures 9, 10, 11, and 12 by typical polarograms. In each case a small amount of CO₂ has been bubbled through the solution making its concentration somewhat higher than in an air saturated solution. The percarbonic acid wave is well apparent on each of the four curves. On Fig. 13 we give three polarograms obtained with 0.1 normal KNO₃ containing 22 milligrams of Kahlbaum potassium percarbonate in 10 cc. of solution. In the height of the percarbonic wave increases from curve 1 to curve 3 showing that the acid is released slowly by hydrolysis. This wave is essentially the same as that obtained with CO₂-H₂O₂ mixtures. Detailed data are given in Table II.

TABLE II
Polarographic Waves of Potassium Percarbonate
(Data for Fig. 13)

Number of Curve	Time Started	POTENTIALS	
		Initial	Final
1	9.46	0.00	1.55
2	9.56	0.00	1.55
3	10.06	0.00	1.38

The potentials are referred to a mercury anode covered with the solution investigated. Nitrogen was bubbled to eliminate atmospheric oxygen. Nevertheless oxygen waves are present on account of the formation of O₂ from H₂O₂ or from the percarbonate.

Polarographic Reduction Waves of Carbon Dioxide.

Our discovery and interpretation of the high po-

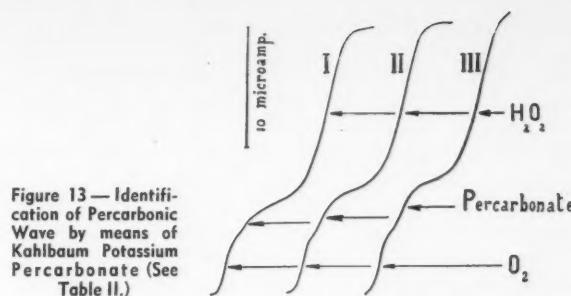


Figure 13—Identification of Percarbonate Wave by means of Kahlbaum Potassium Percarbonate (See Table II.)

tential reduction of carbon dioxide have been presented in previously published papers. (See Ref. 2). Before undertaking corrosion studies in presence of CO₂ we attempted to obtain additional evidence for the relationship between the CO₂ diffusion current and the concentration previously obtained on the basis of rather fragmentary data, namely

$$i_d = 2.12 \times C_{CO_2} \text{ microampères}$$

in which the concentration of CO₂ is in millimoles per liter. The formula applies to 0.1 normal solutions of tetramethylammonium bromide in the neighborhood of 25°C and for a capillary with characteristics such that the factor $m^{2/3} t^{1/6}$ in the Ilkovic equation is 2.5. The use of a quaternary ammonium salt as a supporting electrolyte in CO₂ determinations is required because of the high reduction potential of CO₂: 2.10 volt with respect to a mercury anode covered with the supporting electrolyte. The possibility of using lithium or magnesium salts as supporting electrolytes was gone into to a certain extent but does not seem promising on account of the closeness of the reduction potentials of lithium and magnesium ions to that of CO₂. For rather small amounts of CO₂ it might be possible to obtain CO₂ waves sufficiently distinct from the final rise of current due to lithium or magnesium ion reduction. In any case potassium and sodium salts are out as far as CO₂ determinations are concerned. The difficulty in checking the formula above by means of quantitative chemical determinations of CO₂ is that most solutions are supersaturated

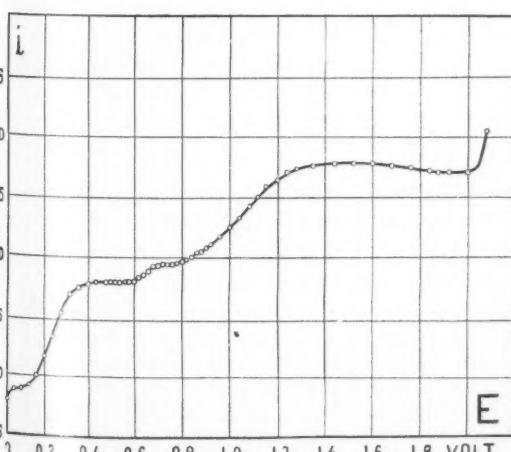


Figure 11—Polarogram of O₂ + CO₂
(CH₃)₄N Br. 0.1N Sens: 1 div. = 0.322×10^{-6} A
O₂: 9.2 Mg./L Anode: Hg
CO₂: 1.3 Mg./L

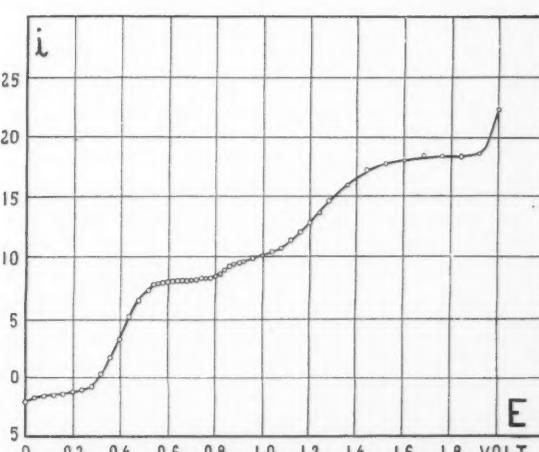


Figure 12—Polarogram of O₂ + CO₂ in Sea Water
O₂: 7.6 Mg./L Sens: 1 div. = 0.322×10^{-6} A
CO₂: 0.66 Mg./L Anode: Hg

with respect to CO_2 and losses occur during the manipulations and the analysis. Nevertheless we have obtained several good checks of the coefficient of proportionality between the CO_2 reduction current and the concentration. Another difficulty with CO_2 waves is that it is often not possible to obtain a good definition of the position of the diffusion current, either because of the maximum which appears above a certain CO_2 concentration or because of too rapid a merging with the final reduction current of the quaternary ammonium ion. In our previous work we have been able to determine the half-wave slope of CO_2 waves and we have shown that it is remarkably constant over the whole range of concentrations and equal to 0.352, provided the Ri correction for the ohmic drop of potential is made or is found negligible. In this connection it is advisable to use cells with a mercury anode in the cell itself in order to avoid the large resistance present when one uses a separate anode connected with the polarographic cell by means of a salt bridge. The known slope of CO_2 waves can then be used in a very convenient method of determining the diffusion current which avoids the difficulties mentioned above: on the basis of a few experimental points in the neighborhood of the half-wave (2.10 volts) in the case of the manual method, or on the basis of the half-wave region of the continuous curve in the case of the photographic method, one draws a straight line which is the tangent to the wave at the half-wave potential. From the point of intersection of this straight line with the axis of applied potentials one marks, to the right, a distance equal to 0.352 volt and one measures the vertical height from that point to the tangent at the half-wave. This distance is the diffusion current of CO_2 . This method makes it possible to determine the CO_2 current by taking only a few points (in principle two or three are sufficient) near the half-wave, drawing the best possible straight line through these points and performing the geometrical construction just described. Very rapid determinations of the consumption of CO_2 by metals can thus be carried out.

When O_2 is present along with CO_2 the formation and the reduction of percarbonic acid have to be taken into account in the determination of the total CO_2 . If the total amount of CO_2 is very small, for instance the 0.4 milligram in an air saturated solution, there will be a percarbonic acid current of the order of 1 microampere (about five times the current which an equal molar concentration of O_2 would give) while the same amount of CO_2 in the absence of O_2 would give a current at 2.10 volts of only about 0.02 microampere which it would be impossible to detect. If the concentrations of O_2 and CO_2 are about the same, say 10 milligrams per liter each, the first O_2 current is about 5 microamperes, that of percarbonic acid is still of the order of 1 microampere, that of CO_2 at 2.10 volts would be theoretically about 0.5 microampere but the accumulation of hydroxyl ion near the cathode due to the reduction of oxygen may considerably reduce the CO_2 current. We have shown in our previous work (Ref. 2) that the bicarbonate ion does not reduce. When the CO_2 concentration is

much larger than the O_2 concentration the percarbonic acid complications are negligible but the accumulation of hydroxyl ion may still be appreciable, particularly if the time involved in the measurements is considerable and makes possible an appreciable electrolysis of oxygen.

From the point of view of corrosion studies in presence of CO_2 we have to distinguish between tests in presence of large amounts of CO_2 without any O_2 present, tests in presence of comparable amounts of CO_2 and O_2 , and finally tests in presence of CO_2 and O_2 in the proportions in which they are present in air saturated solutions.

The problem of quantitative determinations of CO_2 by means of the percarbonic wave has not been solved so far.

No quantitative use of the height of the percarbonic wave has been made in our corrosion studies so far. On the other hand some very interesting qualitative observations have been made which, when extended and made more quantitative, may throw some light on a possible role of percarbonic acid in corrosion phenomena.

In connection with the use of quaternary ammonium salts in polarography, the interpretation of their reduction, etc., the reader is referred to two other contributions from this Laboratory (Van Rysselberghe and McGee, Ref. 12; Gropp, Ref. 13).

Suppression of the Maximum of the First Oxygen Wave.

In most of our polarograms a small amount of methyl red was used as maximum suppressor for the first oxygen wave. Various solutions of methyl red in alcohol as well as aqueous solutions of the potassium salt of methyl red were used in amounts of one to three drops to 10 milliliters of supporting electrolyte solution. Other maximum suppressors used included fuchsin, alizarin, methylene blue, thymol, gelatin, etc. Polarograms taken with both fuchsin and alizarin exhibit percarbonic waves similar with those registered in presence of methyl red, while with thymol the percarbonic wave appears only in basic solutions. Methylene blue and gelatin do not give the percarbonic wave. Apparently specific surface active substances are necessary to allow the reduction of percarbonic acid and the subsequent cycles of reduction and reformation. This problem requires further examination and discussion. It was also noted that small amounts of magnesium ion (in concentrations of the order of 10^{-4}) suppress the oxygen maximum and also the appearance of the percarbonic wave. If methyl red is added to this small amount of magnesium ion, the percarbonic wave is detectable. For a detailed discussion of absorption and suppression of maximums of current-voltage curves the reader is referred to an interesting monograph by Heyrovsky (Ref. 14).

In a subsequent communication we shall present the essential observations made in our application of the polarographic method to the corrosion of several metals and alloys.

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[The authors intend to publish a series of papers dealing with the applications of the method in Corrosion. In the meantime details are available in reports to the Office of Naval Research and in various theses deposited at the University of Oregon library. A general presentation of the method was also given in the November 15, 1948 number of Research Reviews of the Office of Naval Research. Other fundamental developments of this work will be found in the following papers:

Paul Delahay, "Portable Electronic Instrument for Polarographic Measurements and Amperometric Titrations," *Analytical Chemistry*, **21**, 1425-6 (1949).

"An Experimental Study of the Characteristic Features of Oscillograph Polarography," *J. of Phys. and Colloid Chem.*, **53**, 1279-1301 (1949).

"An Oscillographic Polarograph for High Rates of Potential Variation," Accepted by the Journal of Physical and Colloid Chemistry.

"Reversibility and Irreversibility of Electrode Reactions in Oscillographic Polarography. The Validity of the Wave Height Equation," Accepted by the Journal of Physical and Colloid Chemistry.

"A Polarographic Method for the Indirect Determination of Polarization Curves for Oxygen Reduction on Various Metals," in Three parts. Submitted to the Journal of the Electrochemical Society.

Pierre Van Rysselberghe, Paul Delahay, Armin H. Gropp, John M. McGee and Robert D. Williams, "Polarographic Observations on Percarbonate Acids and Percarbonates," Accepted by the Journal of Physical and Colloid Chemistry.]

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13. Van Rysselberghe, P. and McGee, J. M., *Journ. Amer. Chem. Soc.*, **67**, 680 (1945).
14. Heyrovsky, J., "Adsorption, Electro-Reduction and Overpotential," (in *Actualités Scientifiques et Industrielles*, No. 90). Hermann, Paris, 1934.

NACE REPRINT PRACTICE

Requests for prices on reprints of material appearing in **CORROSION** should be addressed to Norman Hamner, Managing Editor, National Association of Corrosion Engineers, 919 Milam Building, Houston 2, Texas. Prices usually cannot be given until after articles have appeared in **CORROSION** although requests for prices may be submitted at any time. Type from which technical articles are printed is kept standing for 90 days after date of issue, and reprints ordered during that interval will be from standing type. For

reprints ordered after expiration of this period, write for details.

Permission to reprint articles usually is given to responsible firms and individuals who wish to have the work done themselves. NACE requires, however, that proper credit be given **CORROSION** at an appropriate place on all reprint material. The association also requests that reprint style closely conform to that approved by its board to be in keeping with the aims and objectives of the association and that copies of reprints made under this authority are supplied NACE for recording purposes.

Condensation of First Interim Report on Ground Anode Test of Sub Committee TP-3—Anodes for Impressed Currents*

A report on the installation procedure, operating data, and preliminary conclusions obtained from the first year of a test to be conducted over a four-year period.

Sixty anodes, four each of the following types were installed in four different ground beds with backfills as indicated:

Ground Bed No. 1—Greenville, Miss.

Size	Type	Anode	Backfill
4" x 80"	Carbon		Natural Soil
4" x 80"	Graphite		Natural Soil
4" x 80"	Steel Pipe		Natural Soil
4" x 80"	Graphite		Natural Soil & Gypsum

Ground Bed No. 2—Jackson, Miss.

2" x 80"	Graphite		Coke Breeze
2" x 80"	Graphite		Graphite
2" x 80"	Graphite		Graphite & Lime
2" x 80"	Steel Pipe		Coke Breeze

Ground Bed No. 3—Greenville Miss.

4" x 80"	Graphite		Natural Soil
2" x 80"	Steel Pipe		Coke Breeze
2" x 80"	Graphite		Coke Breeze & Lime
2" x 80"	Graphite		Graphite

Ground Bed No. 4—Jackson, Miss.

2" x 80"	Graphite		Coke Breeze
4" x 20"	Graphite		Coke Breeze
2" x 80"	Carbon		Coke Breeze

The installation data on each ground bed include location and detail sketches with dimensions relative to anode positions and location of adjacent lines. In addition, a table of soil resistivity measurements obtained by the soil-box and four-pin method are included for each ground bed location. Composition of backfill material with resistivity measured by the soil-box method gives some indication of the relative properties and effects of the different backfills. Immediately after installation, current measurements and pipe-to-soil potentials were measured to determine the extent of interference from any adjacent pipe lines which are not a part of the test set-up. From the measurements recorded, calculations were made to determine the anode resistance required in each individual circuit to properly balance the overall circuit and provide uniform currents to the individual anodes.

At the end of the first year's test, one anode of each type was removed and examined. Steel pipe anodes were cleaned and weighed to determine weight loss. Photographs in the complete report illustrate the typical appearance of each type anode at the time of removal. Tables of current and resistance measurements taken at intervals of one month during the test are presented by curves with the operating data plotted versus time.

* This is a summary of the contents of the named report prepared by central office staff. The full interim report is in print at Central Office, National Association of Corrosion Engineers, Houston, Texas.

Conclusions

From the data obtained on the first year's test, the following preliminary conclusions are presented:

1. Effect of backfill other than soil:

- (a) Lowers resistance to ground as compared with the use of natural soil
- (b) Increases anode life
- (c) Allows greater current capacities per anode
- (d) Reduces effect of gas blocking
- (e) Tends to make anodes function uniformly

2. Performance of anodes:

- (a) Graphite has a longer life than carbon
- (b) Both carbon and graphite should have a longer service life than steel when current densities are comparable
- (c) The theoretical voltage advantage of steel pipe anodes is not confirmed in this test. Apparently the actual life of a steel anode as compared to theoretical is offset by increased voltage requirements in excess of theoretical
- (d) Anode attack varies directly with current density.

It is hoped that further observation will determine the advantage of mixing lime with carbon or graphite backfills. No loss or settling was observed on the carbon or graphite backfills. Subsequent tests may determine whether or not the lower resistance of a gypsum and soil backfill as compared with a natural soil backfill compensates for the apparent increase in anode attack. Present data are not sufficient to determine the effect of low pH conditions of gypsum backfill in comparison with other type backfills.

This report is the first published by the Committee on the results of the extensive tests being conducted at five locations under the direction of five co-operating companies in collaboration with a leading manufacturer of carbonaceous anode and backfill materials. Conclusions developed are tentative. The scope of the Committee is limited to the testing of ground bed materials where a direct impressed current is applied. No effort is being made or contemplated to evaluate the efficiency of galvanic anode materials or the degree of protection afforded the underground structure as both of these subjects fall within the scope of other Association committees actively engaged in cathodic protection research.



Topic of the Month

A Protective Relay for Selenium Rectifiers

Used as One-Way Valves

In Electrolysis Drainage Wires

By W. D. CONNON*

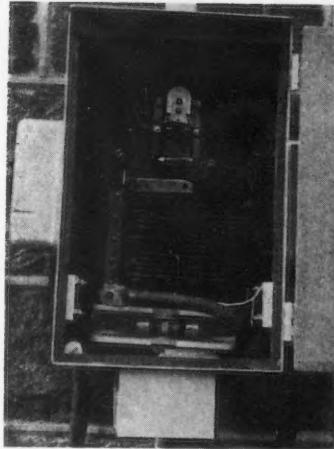


Figure 1—Selenium valve installation equipped with reverse potential relay.

THE use of dry disk rectifier stacks as one-way valves in electrolysis drainage wires has been somewhat limited by the fact that excess voltages in the reverse direction will damage the rectifying elements and thus involve an expensive replacement of the entire unit. Trouble of this nature has been materially reduced by the use of selenium units which can safely withstand a reverse potential of 20 volts, as compared with a maximum of approximately six volts for copper oxide rectifiers. Further protection can be obtained by connecting two or more units in series but this arrangement has the very obvious disadvantage of increased cost for the additional units, and greater electrical resistance in the forward direction which may make the overall design impracticable.

A solution of the problem indicated above has been found by the application of a reverse potential relay circuit to a conventional selenium valve unit. This new circuit arrangement functions in

such a way that the electrical path through the rectifier unit is broken when the reverse potential exceeds 15 volts. Figure 1 is a photograph of an installation which has been modified to include this protective feature and Figure 2 shows a simplified schematic diagram of the circuit, which operates as follows:

Under normal conditions, the underground cable requiring protection is positive to the negative bus of the D.C. trolley substation. Current flows from the cable through the normally operated contacts of the relay and the selenium rectifier to the trolley bus. Some current also flows from cable to bus through the relay winding but it never becomes large enough to operate the relay and open its contacts because the potential drop across the rectifier unit remains relatively constant at a low value (1-2 volts). This holds true, even for large amounts of drainage current, because it is an inherent characteristic of selenium rectifiers that their resistance decreases as the current through them increases.

When power conditions develop which make the trolley bus positive to the

underground cable, practically the entire voltage is applied to the relay winding because the rectifier has a high resistance in the reverse direction. If this voltage does not reach the operating potential of the relay (16 volts) the selenium unit functions in the normal manner, limits the reverse current to a low value and is not subject to damage. However, if the potential exceeds the rated operating potential of the relay, its contacts will open and reduce the potential across the rectifying units to zero, thereby protecting it from damage due to excessive reverse voltage. After the relay has operated, it will not release until the applied voltage has dropped to 3 or 4 volts, because there is a wide margin between "operating" and "holding" currents. This eliminates the tendency towards relay chatter at a critical voltage. Furthermore, operating characteristics are such that the current through the relay contacts is normally low at both the "make" and "break" periods so that a minimum amount of arcing and burning takes place. These factors not only reduce maintenance costs but also make possible the use of relatively inexpensive relays.

It has been learned recently that a French engineer described in a French publication in 1948 a circuit for electrolysis protection almost identical to the one covered in this paper.¹ While the facts are not known, it is quite probable that excessive damage to operating units because of high reverse voltages was the motivating force in his case, as well as our own, to develop a method for the elimination of this type of trouble.

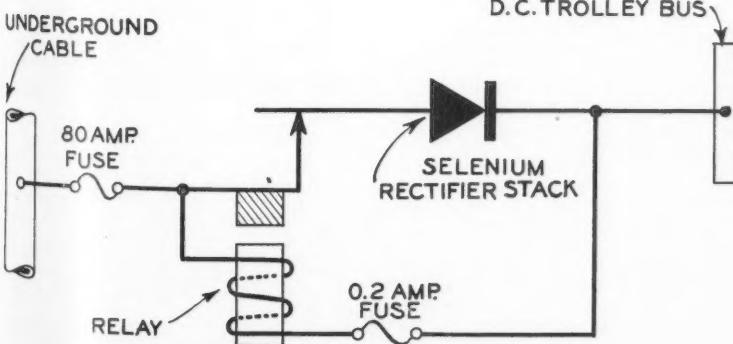
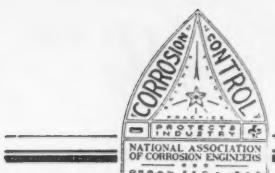


Figure 2—Schematic wiring diagram of rectifier unit and relay.

1. Protection Cathodique des Canalizations Souterraines M. René Brouwer, Commission Mixte Internationale, Document No. 46-B-25.



NACE News



For President
VANCE N. JENKINS
Research Supervisor, Union Oil Co. of California



For Vice-President
N. E. BERRY
Director of Research, Servel, Inc.



For Treasurer
R. A. BRANNON
Supervising Corrosion Engineer, Humble
Pipe Line Co.

Nominations for 1950 NACE Officers Are Made

Petition is Filed for First Student Section

Bureau of Mines Portion Of TP Report Approved

The Bureau of Mines contribution to the report of TP-1 on Condensate Well Corrosion has been approved for publication by the bureau. The completed report now is being prepared by NACE for reproduction and a summary, intended for publication in CORROSION, has been prepared and is being reviewed by committee members, prior to submission to the editor of CORROSION for approval.

It is not possible to say now when the finished report will be issued, but it is the intention of all interested in the production aspects of the problem to expedite it. Policy decisions respecting distribution are being sought and it is expected a full statement of distribution procedure will be issued soon.

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National Bureau of Standards has developed a system of mounting metallurgical specimens at room temperatures through use of a polymer and monomer, which when mixed in proper proportions, will polymerize or set at room temperature.

A petition has been filed for recognition as a local section of NACE by a group of engineering students at the University of Houston. Fifteen charter members, mostly junior members, met January 24, adopted by-laws and elected officers. This is believed to be the first group in the United States to seek recognition as a student section.

Officers elected were W. G. Boyd, Jr., Galveston, Texas; M. F. Krch, Houston, vice-chairman; E. J. Mulvaney, Jr., Pasadena, Texas, secretary; E. O. Bammel, Jr., Houston, treasurer. These officers were elected to serve until the fall semester when another election will be held.

John P. Roberts, associate professor of metallurgy at the university, and an NACE member, was named senior faculty adviser by the students.

Errata Noted

Errata in "Cathodic Protection—A Symposium" issued last year by NACE have been noted as follows:

Page 102—Copy headed "Table 5" does not belong to the article to which it appended and should be stricken out.

Page 130—Photograph of magnesium anodes on this page should be considered along with "Current Output of Light Metal Galvanic Anodes," beginning on page 101.

Nominated for national NACE offices, according to the provisions of paragraph three of Section Three, Article VIII of the articles of organization are the following named by a committee consisting of the president, vice-president, past president and members representing regional divisions of the association:

For President: Vance N. Jenkins, Union Oil Co. of California, Wilmington, Cal.

For Vice-President: N. E. Berry, Servel, Inc., Evansville, Ind.

For Treasurer: R. A. Brannon, Humble Pipe Line Co., Houston, Texas.

For directors, 3-year terms, representing active members: H. D. Murray, Cren-Ray Plastic Products Co., Midland, Texas; Aaron Wachter, Shell Oil Development Corp., Emeryville, Cal.

For director, 3-year term, representing corporate members: V. V. Malcom, The Philip Carey Mfg. Co., Lockland, Cincinnati, Ohio.

Letter ballots already have been mailed to the membership and a committee consisting of the executive secretary and tellers named by the president will canvass the returned ballots and make a certificate as to the number of ballots cast for each person. This certificate will be delivered to the president at the annual conference and he will report results of the voting.

Officers declared elected will take office at the beginning of the last day of the annual conference.

NACE CALENDAR

BALTIMORE SECTION—Dinner meeting March 22, Park Plaza Hotel, 6:30 p.m. Program: "History of Stray Current Electrolysis Mitigation and Cathodic Protection."

CHICAGO SECTION—Meeting scheduled March 15.

CLEVELAND SECTION—March. M. G. Fontana, chairman, Department of Metallurgy, Ohio State University. Joint meeting with American Institute of Chemical Engineers.

GREATER ST. LOUIS SECTION—March 20. Scheduled speaker R. H. Brown, Chief, Chemical Metallurgy, Aluminum Co. of America, New Kensington, Pa. "Possible applications of Aluminum as Demonstrated by Corrosion Test Data."

HOUSTON SECTION—March 14. "Protection of Offshore Drilling Structures," by E. L. Doremus, et al.

NORTH EAST REGION—Philadelphia, March 14.

PHILADELPHIA SECTION—Dinner meeting March 14, Penn Sheraton Hotel, 6:30 p.m. Program: "Titanium—a New Structural Metal," and "Kel-F—A New High Temperature and Chemical Resistant Thermoplastic."

R. H. Brown and O. C. Mudd Are Named to Get 1950 NACE Whitney and Speller Awards

R. H. Brown, Assistant Chief, Chemical Metallurgy Division, Aluminum Research Laboratories, Aluminum Co. of America, New Kensington, Pa., has been selected to receive the 1950 Whitney Award for achievement in the field of corrosion science and O. C. Mudd, Senior Corrosion Engineer, Shell Pipe Line Corp., Houston, Texas, has been selected to receive the 1950 Speller Award for achievement in the field of engineering. Both awards will be presented to the recipients at the annual membership banquet scheduled to be held during the 1950 conference in St. Louis.

Mr. Brown has been engaged in corrosion work for 20 years, fourteen of which were with Aluminum Company, and two as research associate in corrosion engineering, Research Laboratory of Applied Chemistry, Massachusetts Institute of Technology. He has a BS in chemical engineering from Drexel Institute of Technology and an MS in chemical engineering from MIT. He is author of many technical papers on corrosion and has been an NACE member since 1945.

Mr. Mudd, who has been engaged in corrosion work for about 17 years, in investigation, protective measures and research, is one of the founders of NACE. He holds a degree in electrical engineering from Montana State College. He is author of several technical

articles dealing with the protection of underground structures.

Named after Willis Rodney Whitney and Frank Newman Speller, first to receive the awards in 1947, they have been awarded since as follows:

Whitney Award: 1948, Ulrich R. Evans; 1949, R. B. Mears.

Speller Award: 1948, John M. Pearson; 1949, F. L. LaQue.

Selection of recipients was accomplished by the board of directors.

Armour Foundation Seeks Inhibitors for Brine

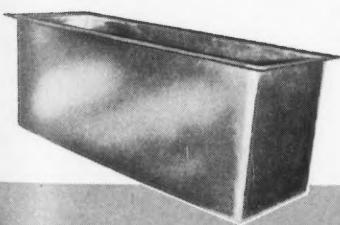
An efficient means of adding corrosion inhibitors to the brine effluent from refrigerator cars is being sought by Armour Foundation for the American Association of American Railroads. The foundation states the brine causes an estimated annual loss of several million dollars in corrosion damage to track and structures.

The most effective inhibitor found thus far is slightly toxic, making it necessary to add it to brine as it leaves the car. The technique of adding the exact amount is the chief problem. Investigation of reputedly non-toxic inhibitors is being undertaken at the same time.

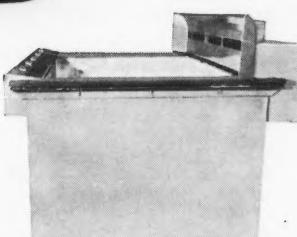
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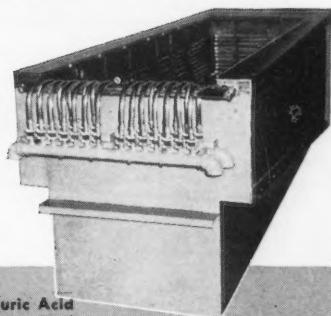
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New York University's division of general education announces a program in Surface Technology for the spring term 1950. Two courses are offered: "Fundamentals of Paint, Varnish and Lacquer Technology," under Elias Singer and "Technology of Organic Finishes and their Applications," by Myron A. Coler.

North East Sections Are Surveyed on '50 Schedule

North East Region section of NACE have been asked by T. P. May, chairman of the Metropolitan New York Section to present a tentative schedule of meetings and programs for 1950-51 in order that conflicts of dates may be minimized and region officials may be able to schedule their meetings concurrently with section meetings. Mr. May outlines some of the problems faced by the region in correlating the activities of the three nearby sections of New York, Philadelphia and Baltimore. He points to the possible difficulties that may arise when a new section is formed in western New York state.

It is further desired, Mr. May points out, to provide insofar as practical a variety of subject matter for meetings. With four or more sections holding four or five meetings between September and May, this means there will be about 20 meetings in eight months.

Chairmen are further asked to express their opinions on: 1) how many meetings each section should hold yearly, 2) how they should be timed, and what the program should include, 3) ideas respecting joint region-section meetings.

Tentative program for the Metropolitan New York Section includes five meetings beginning in September and ending in May, tentative dates being September 20, November 1, December 6, February 1 and May 10.

Topics under consideration for programs include: two speakers on microbiological corrosion, round table on cathodic protection, theoretical approach to some corrosion problems, high temperature corrosion, stainless steels, aluminum alloys, and spray testing.

North East board of directors contemplates six meetings yearly, some of which will be jointly with sections. Tentative 1950 schedule is: March 6 or 7; May 4 or 5; September 4 or 5; October 19 or 20 and December 4 or 5.

Two Joint Region-Section Meetings Are Planned

A schedule of meetings for the board of trustees of North East Region was adopted at the board's January 26 session held at 4 Irving Place, New York City. Joint region-section meetings will be held in the spring and fall this year, the first sponsored by the Metropolitan New York Section on May 10, at New York and the second in November or December, possibly to be sponsored by the proposed Western New York Section.

Section officers were requested to submit to the region a calendar of events for publicity and coordinative purposes.

Mr. F. L. LaQue suggested that G. L. Cox of Rochester and W. O. Binder of Niagara Falls be enlisted to aid in the formation of the Western New York Section. L. B. Donovan reported a survey of NACE membership in the New England area indicates a tremendous potential and R. H. Coe suggested permission to present the NACE story to their members be asked of the New England Gas Association and the New England Water Works Association.

Mr. Coe suggested interest in advertising in CORROSION be stimulated among section members. R. H. Lynch proposed the publication be emphasized in answering advertisement surveys. At next meeting of the trustees, Mr. Donovan is scheduled to appoint a trustee to be responsible for advertising.

Mr. Lynch gave an informal report on recent meetings of the NACE board of directors, and there was a discussion relative to the location of the 1952 meeting. Trustees agreed, following a discussion of the status and relations of regions and sections that best interests of the association would be served in North East Region by maintaining present policy under which chief activities follow in a sectional classification with the region performing a coordinative function.

Tentative schedule of meetings was set as follows: March 14, Philadelphia; May 10, New York City; September 12, Philadelphia; October 19, location undecided; December 6, New York City.

Also present at the meeting were R. R. Pierce, F. J. LeFebvre, G. E. Best and E. R. English.

Metropolitan New York Section heard W. Z. Friend of the International Nickel Co., Inc., speak on "Developments in the Use of Metals and Alloys in the Chemical and Process Industries," at its February 8 dinner meeting at Building Trades Employers' Association, 2 Park Ave., New York City. Mr. Friend described metals and alloys with special applications under extreme temperatures, pressures and when subjected to highly acid solutions and atmospheres.

CORROSION magazine seeks for publication notices of meetings of associations other than NACE which conduct corrosion investigations and research work. Members who know of such activities not reported in CORROSION are asked to notify Central Office so steps may be taken to publish the information.

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These regular meetings normally will consist of a dinner and an evening program consisting of not over two technical papers or a combination of a motion picture and a technical discussion.

The regular March 20 spring meeting at the Engineers Club, William Penn Hotel, will be featured by a dinner, followed by a paper on "Reconditioning of Existing Pipe Lines," by Wayne Schultz of Morain Construction Co., Youngstown, Ohio, followed by a Technicolor motion picture entitled "Underground River" to be furnished through courtesy of Magnolia Pipe Line Co. Mr. Schultz's talk will deal with pipe line practices in the Michigan area.

Notices for the meeting will be sent out a month before and immediately before the meeting. Nominations for section officers will be included in the first notice.

A nominating committee was named by President Russell H. Coe as follows: Kenneth Tator, chairman; Norman P. Peifer and Richard Rimbach.

Several ASTM Meetings

Cover Corrosion Topics

Meetings of the American Society for Testing Materials believed to be of interest to NACE members include:

March 8—Philadelphia District (Air Pollution), Philadelphia, Pa.

March 20 (week of)—Committee D-20 on plastics, Old Point Comfort, Va.

March 21-22—Committee D-12 on Soaps and Other Detergents, New York, N. Y.

March 28—St. Louis District (Stress Analysis in Action), St. Louis, Mo.

April 27-28—Committee D-10 on Shipping Containers, Madison, Wis.

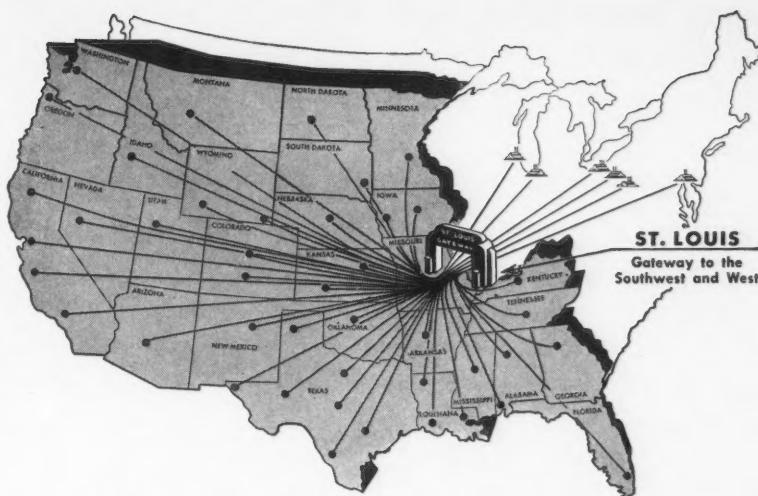
June 26-30—53rd Annual Meeting and 9th exhibit of testing apparatus and equipment, Atlantic City, N. J.

(Tentative 1951 and 1952 meeting dates and places are 1951—Atlantic City, June 18-22; 1952—New York City, June 22-27.)

Philadelphia Section to

Hear Talk on Titanium

Two topics, "Titanium—A New Structural Metal," and "Kel-F—A New High Temperature and Chemical Resistant Thermoplastic" are scheduled for discussion at the March 14 meeting of Philadelphia Section. The dinner will begin at 6:30 p.m. at the Penn Sheraton Hotel, Philadelphia, and the meeting at 7:30 p.m.



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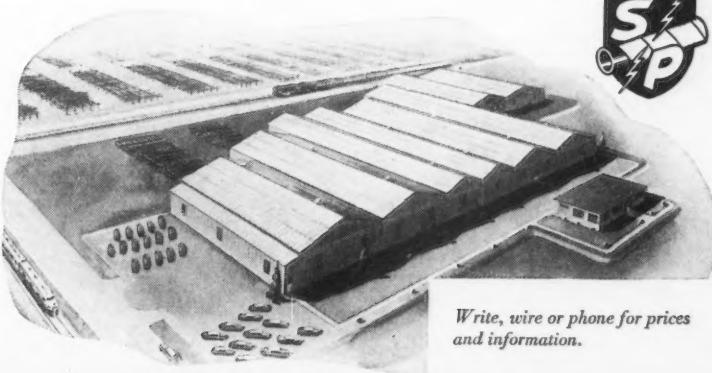
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Stray Current Electrolysis Is Topic at Baltimore

"History of Stray Current Electrolysis Mitigation and Cathodic Protection," will be the subject of an address by E. R. Shepard of the Office of Chief of Engineers, Department of the Army, Washington, D. C., at the March 22 dinner meeting of Baltimore Section. The meeting will open at Park Plaza Hotel, Baltimore, at 6:30 p.m.

Reservations may be made with George E. Best, secretary-treasurer.

Hot Dip Galvanizers' Annual Meeting Held

The 1950 annual meeting of the American Hot Dip Galvanizers Association, Inc. was held at Cincinnati, Ohio February 15 and 16. Stuart J. Swensson, secretary-treasurer of the association reported that specifications have been revised, investigations into several problems made and promotional and advertising plans conducted. Besides the regular committee meetings two reports by guest speakers were heard: "The Preparation of Iron and Steel for Hot Dip Galvanizing," by A. E. Chester, Azed, Inc. and "The Application of Low Frequency Electric Induction Furnaces to Galvanizing Operations," by Edward W. Burd, Ajax Engineering Corp.



Tulsa Section officers installed at the club room of Michaelis Cafeteria, Tulsa, Okla., January 30 were (left to right): Dr. Franklin T. Gardner, professor of chemistry, Tulsa University, chairman; F. E. Pyeatt, Jr., chief engineer, Mid-Continent Pipe Line Co., vice-chairman and Frank E. McNulty, representative of Pittsburgh Coke and Chemical Co., secretary-treasurer. Principal speaker at the meeting was F. A. Prange, Phillips Petroleum Co., who discussed "Corrosion Aspects of Process Plant Design." About 80 members and guests were present.

"Factor of Ignorance" in Corrosion Design Noted

The "Factor of Ignorance" in designing equipment is a principal reason for physical over-design and over-alloying many structures or vessels, Frank W. Davis, chief metallurgist for E. B. Badger & Sons Company of Boston, Mass., told the Greater St. Louis Section NACE at its January 16 meeting. Mr. Davis' topic was "Some Aspects of the Design and Fabrication of Equipment for Corrosion Service."

For example, Mr. Davis said, in designing pressure vessels for ASME code work a "safety factor" of 5 is used. From a corrosion standpoint, even this criterion is lacking. Previous experience and short time laboratory tests must be relied on.

To emphasize the lack of data and necessity for relying on experience, Mr. Davis cited several examples of failures in which solutions were reached through trial and error. Problems encountered in welding pure silver were solved by changing to heliarc welding. Cold forming was the source of trouble in an austenitic stainless steel steam generator and on a martensitic stainless bubble cap application which led to failure by stress corrosion.

In addition to design and fabrication errors, failures are brought about by misapplication of equipment, improper operation and improper maintenance and replacement of expendable parts by the customer, he said.

South East Region Meet Is Changed to April 14

The spring South East Region meeting will be held on April 14 instead of March 15 as previously announced. R. B. Mears will be dinner speaker on "Localized Corrosion." Further program details will be announced later.

Chicago Section Hears Furfuryl Alcohol Talk

E. A. Reineck, from the Chemical Division of Quaker Oats Company is scheduled to deliver at the February 14 meeting of Chicago Section NACE a paper entitled "Furfuryl Alcohol—a Material for Corrosion Resistant Construction." This paper's subject matter includes the nature of furfuryl alcohol chemistry and its resin formations, general characteristics of these resins and commercial applications of furfuryl alcohol resins in corrosion resistant construction.

Approximately 80 attended the January 4 meeting "New Members' Night" to hear Dr. R. B. Mears speak on "Passivity and Inhibition." Six applications for active membership in NACE were received at this meeting.

March meeting of the section is scheduled on the 14th.

Mechanisms and Function Of Inhibitors Explained

Mechanisms and function and protective characteristics of scales, films and adsorptive inhibitors were explained briefly and some results from recent research at the University of Texas using organic and inorganic inhibitors were outlined by Dr. Norman Hackerman of the University of Texas February 14 at the Houston Section meeting. Sixty-five members and guests were present at Elliott's Steak House for dinner. An informal discussion preceded Dr. Hackerman's talk entitled "Corrosion Inhibition by Film Formation."

Also mentioned was some recent work at the University of Texas using radioactive sulfur and carbon compounds. The lecture was accompanied by slides showing curves of some inhibitors' adsorptive characteristics.

Transportation arrangements for those planning to attend the St. Louis conference in April were considered and tentative plans were announced for a tour of Dow's Freeport plant.



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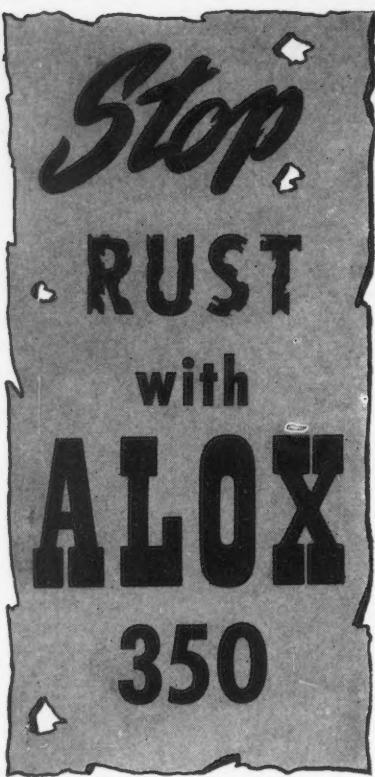
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New Houston Section officers have been named as follows: Oliver Osborn, Dow Chemical Co., Freeport, Texas, chairman; P. P. Spafford, Stanolind Oil & Gas Co., Houston, Texas, vice-chairman; Layton C. Tugle, Shell Oil Refinery, Houston, Texas, secretary-treasurer; Jack Battle, Humble Oil & Refining Co., Houston, Texas, ex-officio board member. Lyle R. Sheppard, Shell Pipe Line Corp., Houston, Texas, was named a member of the Houston Engineers' Council.

North Texas Section held a business meeting January 27 at the Dallas Power and Light Co. auditorium which was followed by the showing of a film entitled "Combating Corrosion with Magnesium, the Metal from the Sea," shown by courtesy of Dowell, Inc.

Corpus Christi Section heard "The General Aspects of Marine Corrosion," a talk by Dr. John G. Campbell, consulting engineer for its January 15 dinner meeting at Crystal Room, Nueces Hotel, Corpus Christi, Texas.

AGA Corrosion Interest Papers to Be Presented

Corrosion-interest papers will be presented April 3-5 by the American Gas Association Distribution Motor Vehicle & Corrosion Conference in Detroit, Mich.

The program has been arranged to concentrate papers of special interest to corrosion engineers on Monday, April 3, thereby giving an opportunity to those who wish to do so to attend the NACE Conference at St. Louis, which officially opens on April 4.

Salt Lake Section's New Officers Elected

Officers of the newly-formed Salt Lake Section elected January 17 at the Mountain Fuel and Supply Co. auditorium, 36 South State Street, Salt Lake City, Utah, are as follows:

Harry R. Brough, Mountain Fuel Supply Co., chairman; George R. Hill, 3725 South 11th East Street, vice-chairman, and John W. Cox, Pipe Line Division, Utah Oil Refining Co., secretary-treasurer.

Twelve members and 12 guests heard Harry E. Rapp of Insul-Mastic Corp., Pittsburgh, Pa., speak on "Gilsenite-Asphalt Coatings Used to Combat Corrosion on Above Ground Structures."

Five members of the section are attending a class on the corrosion of metals conducted by Dr. George R. Hill of the University of Utah.

Changes in officers, or changes in addresses of officers should be brought to the attention of Central Office by secretaries of NACE regions and sections. Changes will be made as soon as possible in the monthly list "Directory of Regional and Sectional Officers."



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TP-1A--Pacific Coast Meeting is Scheduled

E. O. Kartinen, Signal Oil and Gas Co., 811 West Seventh Street, Los Angeles 55, Calif., in a letter to T. S. Zajac, chairman of NACE TP-1 Committee advises that he has scheduled for February 15 a full committee meeting of TP-1A—Pacific Coast, which consists of representatives from 15 oil companies. First business will be a compilation of methods used by Pacific Coast oil companies for the prevention of "down the hole" corrosion.

San Francisco Bay Area Section's February 14 meeting scheduled a paper "Soil Surveys and Pipe Line Corrosion Control," by M. J. Miller, engineering department, Standard Oil Co. of California. The dinner meeting was scheduled to begin at 6:30 p. m. and the general meeting at 7:45 p. m.

Other scheduled items on the program included motion pictures "Steel, Man's Servant," and "1949 Football Highlights."

Comments on CORROSION From the Nation's Daily Newspapers

AUTOMOTIVE ENGINEERING CORROSION PROBLEMS ARE SUBJECT OF DISCUSSION

(From American Metal Market, New York, Jan. 7, 1950)

New York. Corrosion problems in automobiles after they are manufactured was the scheduled topic of a talk by F. L. LaQue of The International Nickel Co., Inc. before the Detroit Chapter of the American Society for Metals January 9. His topic was "Corrosion Aspects of Automotive Engineering."

INHIBITOR AND SALT USED TO MELT ICE

(From the Kansas City, Mo. Times, Kansas Star, Dec. 23, 1949)

Kansas City. Salt and a corrosion inhibitor were spread over heavily rutted intersections to thaw out ridges into slush.

LOUISIANA OIL FIELD CORROSION IS STUDIED

(From the Shreveport, La. Times, Dec. 7, 1949)

Shreveport. A group of members of the Ark-La-Tex Chapter of the API heard a comprehensive discussion of corrosion problems in the Cotton Valley field of Webster Parish and how they are being met. Ralph Hock, chief petroleum engineer for the Cotton Valley operators and the Haynesville Operators' Committee, presented data on experiments in the Cotton Valley field. Known loss in equipment in the Cotton Valley field from corrosion was between \$25,000 and \$30,000 annually, he said.

CATHODIC PROTECTION FOR "MOTH BALL FLEET" SEEN

(From Hammond, Ind. Times, Dec. 27, 1949)

The United States Maritime Commis-

NACE NEWS

sion will ask Congress next year for the authority and money to hang plates of magnesium in the water all around the 2,200 merchant ships in the so-called mothball fleet. Officials estimate the magnesium plates will save the government from \$25,000,000 to \$75,000,000.

ANCIENT RUST IS STUDIED BY OSU INVESTIGATORS

(From N. Y. Journal of Commerce, Dec. 30, 1949)

Columbus, Ohio. A special study of 2000-year-old rust to help in the fight against corrosion is being made by Dr. Earl R. Caley of Ohio State University. None of the studies so far have indicated ancient peoples discovered and used any technical methods or produced

any artificial products that cannot be duplicated today, he told the American Chemical Society's annual chemical engineering symposium.

Pittsburgh, Dec. 29—A rust inhibitor will be added to salt used for ice and snow removal at switches and passenger stops on Pittsburgh's street railways. The inhibitor to be used is "Binox" a product of Calgon, Inc.

Notices of future meetings of NACE subdivisions are carried monthly under the heading "NACE Calendar" in each issue of CORROSION magazine. Notices for this column should be sent to Central Office.

CORROSION DIRECTORY

*Rates for notices under this heading can be obtained from
National Association of Corrosion Engineers, 919 Milam Building, Houston 2, Texas*

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PROOF against Acids, Alkalies, Salt, Oil and Water

*Article in C. & E. News Vol. 27 — #39

"Prucoat proven superior to all other coatings we have tested" . . . writes one of America's largest chemical companies, after eight years' experience with Prucoat. And this is just one of many reports on file testifying to the effectiveness of Prucoat's famous liquid plastic formulations in controlling corrosion caused by chemical agents such as these:

Acetic Acid	Muriatic Acid
Alcohols	Nitric Acid
Bleach Solutions	Oleic Acid
Calcium Chloride	Olein
Chlorine	Phosphoric Acid
Cyanides	Salt Solutions
Formaldehyde	Sugar
Hydrofluoric Acid	Sulfonated Oils
Lactic Acid	Sulphuric Acid
Lubricating Oils	Sodium Hydroxide

Send today for a Prucoat PROOF Packet. Contains in one easy-to-file folder outside laboratory tests, case histories, and Prucoat Protecto-Graph Plan for analyzing your own painting maintenance costs. Write Prucoat Laboratories, Inc., 63 Main St., Cambridge 42, Mass.

SAVES More because it PROTECTS More

PRUFCOAT
PROTECTIVE COATING

8 Attractive Colors that Apply Like Paint to Masonry, Metal, Wood

Corrosion Problems

Questions and answers for this heading should be submitted in duplicate if possible, addressed to "CORROSION PROBLEMS", National Association of Corrosion Engineers, 919 Milam Building, Houston 2, Texas. Questions received at the address above will be sent to E. A. Tice, The International Nickel Co., Inc., N. Y., who is acting editor of the page. All questions will become property of NACE. Questions and replies may or may not be published under this heading and may be answered either by mail directly to the person asking the information, or published under this heading, or both, at the discretion of the editorial staff. Answers to published questions are solicited. Authors of questions will remain anonymous to readers, while authors of answers may remain anonymous if they request it.

No. 40—A large brewery employs a 6 percent caustic soda solution for bottle washing. This equipment is located on the third floor of the building. The solution splashes out of the equipment, seeps through the floor, and attacks the concrete structure beneath the floor. Attempts have been made to paint the floor but nothing has been found satisfactory to date. Acid and alkali resistant mortar and tile has not been satisfactory because vibration causes cracks to develop. Is there a practical floor coating that can be applied to the existing installation which will prevent further attack of the concrete structure?

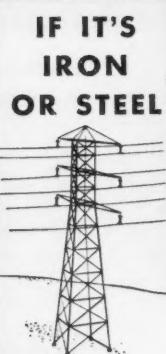
No. 41—Has there been found an effective solution to the problem of under-film corrosion, sometimes referred to as "worm tracking" under organic coatings such as lacquers and varnishes, applied on sheet steel or tin plate?

No. 42—Can someone cite examples to show that corrosion products formed in crevices may exert considerable thrust? In the case of sectional cast iron boilers used in domestic heaters, some evidence has been found to indicate that corrosion products create sufficient thrust to cause leaks at the nipple joints in such sections, despite the use of stay bolts. Considerable rust has been observed on contacting surfaces which normally butt together. Could such products exert a force strong enough to cause leaks to develop?

No. 43—What is the best economical means of preventing corrosion, during shipment and storage, of threads on galvanized pipe and conduit, where the zinc coating has been cut off by automatic threading machines?

No. 44—In cathodic protection of tank bottoms on a petroleum tank farm, would not small individual rectifiers for each tank give more economical and positive protection than larger units protecting a number of tank bottoms?

No. 45—What is the best method of controlling carbon dioxide corrosion in steel condensate pipe lines?



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HOT DIP GALVANIZED

(DIPPED IN MOLTEN
ZINC)

Only HOT DIP Galvanizing provides the heaviest practicable coating of zinc *inseparably bonded* to the steel. For the longest-lasting economical rust prevention, specify "Hot Dip Galvanizing" done by a member of the American Hot Dip Galvanizers Association. List of member plants available by writing to the Association's headquarters in the First National Bank Building, Pittsburgh 22, Pennsylvania.

NEW PRODUCTS—Materials—Service—Literature

"Karbate" impervious graphite globe valves in 1-inch and 2-inch sizes are available now, National Carbon Division, Union Carbide and Carbon Chemical Corp. reports. The valves are designed for shut off and throttling service with corrosive fluids free from abrasive solids. Except for the Teflon packing, all parts in contact with the fluid are Carbate. A descriptive catalog section M-8803-A may be obtained by writing the company at 30 East 42nd St., New York 17, N. Y.

GAMA Industries, Inc., 79 Pine St., New York manufactures to American Water Works Association specifications their GAMA asbestos pipe line felt for use in conjunction with coatings as a wrapping or shield. The material is pure asbestos fiber felted into a dry felt with minimum ingredients other than asbestos. Saturation is with either tar or asphalt depending on the enamel to be used on the line. Maynard H. Jackson of Middle West Coating & Supply, Daniel Bldg., Tulsa, Okla. has been appointed distributor.

"Chemlon" packing for a wide variety of corrosive environments are supplied in numerous styles as molded or braided materials by Crane Packing Co., 1800 Cuyler Ave., Chicago 13, Ill. The company's catalog, "Packing for the Chemical Industry" lists the various styles

and enumerates service conditions for which the material is recommended. The chemically-inert material for valve stems, centrifugal and rotary shafts and reciprocating rods provides efficient sealing protection against escape of liquids, fumes of highly inflammable or corrosive nature.

General Offices of Crutcher-Rolfs-Cummings, Inc., formerly in the Esperon Building, Houston have been moved to 7825 Katy Road, Houston. Office and plant now are at the same location.

Petroleum Mechanical Development Co., has been formed by John E. Eckel and Marvin R. Jones, with offices at 3803 South Main St., Houston.

Consolidated Western Steel Corporation's steel plate fabricating shop at Orange, Texas will be in operation March 1 and the new pipe mill at the same location about March 15. The shop will fabricate mild and stainless steel and nickel-clad vessels for the petrochemical and sugar industries. The pipe mill will produce first 31-foot lengths of 30-inch pipe. Capacity of the mill is 50 miles of pipe monthly.

Gaco Vinyl finishes and coatings are enumerated and listed in a 4-page folder

issued by the Gates Engineering Co., P. O. Box 1711, Wilmington, Del.

Diamond Chromium Chemicals, a 32-page handbook on chromium chemicals has been prepared by Diamond Alkali Co., 300 Union Commerce Building, Cleveland 14, Ohio, for chemists, metallurgists, engineers, production managers, purchasing directors and others. Use of chromium chemicals for corrosion mitigation is explained. Six methods of analyzing sodium bichromate are given. Helpful charts and tables are included.

Brookfield "Viscotrol" units which are designed for engineering into industrial systems where continuous automatic viscosity control is needed have enclosed motors and working parts to prevent corrosion. Under exceptionally severe corrosive environments provision is made for introduction of a continuous air or gas purge. Exposed spindles and shafts can be supplied in any desired alloy. Brookfield Engineering Laboratories is located at Stoughton, Mass.

"Feed-Rator," a unit for simultaneous control, metering and dispensing relatively small amounts of materials into a larger stream, made of transparent acrylic resin, contains a built-in eductor which takes the place of a pump permitting the feeding of many highly corrosive



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UNDERGROUND PIPE WRAP

- Reinforces the pipe coating.
- Retards cold flow in coatings.
- Increases impact strength of most pipe coatings.
- Will not absorb moisture — Glass Fiber is non-hygroscopic.
- Inert to soil chemicals.
- High tensile and tear strength of mat results in simple uniform application.
- Excellent saturation characteristics with all types of pipe coatings.

WRITE FOR BULLETIN NO. V-69

* Manufactured by GLASS FIBERS,
INC., Waterville, Ohio

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MANUFACTURING CO., INC.
2715 Dawson Road, Tulsa, Okla.
Houston - New York - San Francisco

chemicals directly from a container. Details are listed in Catalog 62, Fischer & Porter Co., Hatboro, Pa. This same firm describes in Catalog Section 75 "Level-meter Instruments," a tape and drum magnetic meter for corrosive service with travel up to 25 feet. The device consists essentially of an annular donut-shaped float of non-corrosive material which contains a magnet. This float is free to travel over a closed cylinder extending into the tank. This cylinder has suspended in it from a steel tape, a second magnet. When the level of the liquid changes the magnet contained in the float activates the magnet suspended from the tape, moving it up or down. This tape activates the indicator in the instrument. Readings are accurate to $\frac{1}{4}$ inch. Recording devices can be included. For interface level measurement the float is loaded with shot to the required specific gravity.

Rubber Lined Pipe can be prepared in the field for jointing through use of a tool developed by the Gates Engineering Co., P. O. Box 1711, Wilmington, Del. The tool permits cutting to length, facing, grooving and counterboring the pipe. Brochures on the tool are available on request.

Smith-Blair, Inc., 535 Railroad Ave., South San Francisco, Cal., is offering catalog sections on its cast bronze fast action repair clamp, with Duronite bolts and nuts for resistance to corrosion; a second section on full-circle clamp couplings, for sealing leaks or coupling pipes, which include bonded-in gaskets; and a third on service clamps for steel, cast iron and cement asbestos pipe.

Chemical Resistant coatings are described in a 4-page folder available from The Wilbur & Williams Co., Greenleaf and Leon St., Boston 15, Mass.

Dampney Vinyl coating, recommended by the manufacturers for corrosive environments between -40 degrees F and 160 degree F wet or dry, is insoluble in alcohols, greases, oils, aliphatic hydrocarbons, resistant to alkalies and mineral acids and with low permeability to water vapor and low water absorption is offered in stock shades of clear, black or gray high-gloss finish. The film must be applied in not less than two coats, on a clean surface, and is especially valuable where taste and toxicity control is essential. It air dries in one hour without heat. Further information can be secured from The Dampney Co. of America, Hyde Park, Boston 36, Mass.

Oakite Special Protective oil, information concerning the uses and applications for which are contained in a booklet available from Oakite Products, Inc., 22 Thames St., New York 6, N. Y. will displace water or moisture on metal surfaces, the manufacturers claim. The oil, designed to provide a temporary rust protection to metal parts during production, storage or while awaiting shipment, deposits in a very thin film by dipping, spraying or brushing. The booklet also describes other Oakite products for rust-prevention and surface preparation.

Dresser Manufacturing Div., Bradford, Pa., has added three new buildings to its plant with a combined floor space of 66,000 square feet. The new plant will provide space for full-scale manufacture

of new products, including corrosion shields, special insulating gaskets and Dresser bonds. Space for doubling the Engineering Design and Product Development Laboratories also will be provided.

B. F. Goodrich rubber, oil-resisting, cloth inserted, asbestos, and Koroseal sheeting specifications are listed in Catalog Section 5000-1 available on request from the company's Akron, Ohio, offices.

Duriron Acid-Proof drain line items are given in Price List H-2 and Durco corrosion-resisting fans are listed in Bulletin 1103, both available on request from The Duriron Co., Inc., Dayton 1, Ohio. List H-2 is a major revision of the company's listing of equipment now available for handling corrosive wastes. New and improved items are listed. The most notable design improvements are the use of cap style cleanouts and C-clamps. Previous high silicon iron elements have had cast threads and loose fits. The fan bulletin contains information on the company's fans for handling corrosive fumes, which are built in five sizes up to 7500 cfm. The three larger fans are constructed with an impeller shaft supported on two bearing housings. This permits easier servicing of motors, speed changes through sheave changes, and in some cases the use of smaller horsepower motors.

Lebanon Steel Foundry, Lebanon, Pa., has compiled two steel casting reference charts covering 33 selected grades of carbon and low alloy, stainless, corrosion and heat-resisting alloys. The

Complete Corrosion Prevention Sales and Service

In addition to outstanding corrosion prevention materials, **JAMES E. MAVOR COMPANY** offers you the services and facilities of an experienced organization for the solution of your corrosion problems.

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Stocked at Houston for immediate
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Asbestos Pipe Line Felt
Direct from factory shipment
Also stocked at Houston for
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**Protective Coatings for
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chart covering the stainless and corrosion resistant castings lists 18 grades. Comparable designations of Alloy Casting Institute, American Iron and Steel Institute, ASTM, Hydraulic Institute, SAE and U. S. Navy are given for each grade.

Eriez Non-Electric Agitator Separators, designed to separate small amounts of non-magnetic material from large amounts of magnetic material withdraw about 90 percent of the material separated at the first stage and nearly all of the remainder at the second stage. Agitation is effected by non-magnetic vanes actuated by the passage of alternate slats of Alnico and non-magnetic material set into the face of a pulley. Magnetized particles are carried on a belt to a receptacle, and non-magnetic particles fall directly from the feed chute, passing again the lower face of the pulley where the second separation is effected. The manufacturer is located at Erie, Pa.

United States Steel Corp., 429 Fourth Ave., Pittsburgh 19, Pa., has compiled findings and data on its subsidiary companies and published them in a new 87-page illustrated booklet "Steels for Elevated Temperature Service." Composition, microstructure, grain size, internal stability, embrittlement, corrosion resistance, thermal conductivity, expansion, and the modulus of elasticity are covered. A comprehensive list of U. S. Steel technical literature on steels for elevated temperature use is included.

Fisher Research Laboratory, Inc., 1961 University Ave., Palo Alto, Calif., is producing a 10-lb., metal cabinet cased, low-cost pipe and cable locator designed for field service. The instrument works equally well with inductive, conductive and radio balance methods, the manufacturers claim, and it can be used advantageously over highly conductive ground. The metal cabinets protect the instrument against outside interference, and depth penetration under average ground conditions is approximately 20 feet. Depth of a structure may be determined by triangulation, using a built-in 45 degree level on the instrument. The instrument also will locate stubs and illegal connections, and where multiple structures are buried, a conductive attachment for singling out individual pipes and separating them from the others may be used. Literature, including the company's water well tester for detecting salt water infiltration, and leak detectors is available on request.

Flintkote Co., Industrial Products Div., 30 Rockefeller Plaza, New York 20, N. Y., is offering new product data sheets on Flintkote Trowel Mastic, Bulletin I-C No. 221; Semi-Mastic, Bulletin I-C No. 222; and Plastic Cement No. 232.

"**Polymerized Ethylene Plastic** powders may be sprayed on to metal surfaces with the Schori Process flame pistol, a product of Schori Process Division, Ferro-Co Corp., 8-11 43rd Road, Long Island City, N. Y. The resulting coating is homogeneous with high resistance to most chemicals at temperatures up to 180 degrees F. The company claims adhesion of the sprayed material to the surfaces now is greater than the

tensile strength of the coating. The company has issued and will supply on request Technical Data Sheet No. 103D which covers the use of the pistol, surface preparation, preheating recommendations, characteristics of different coatings available, the "Du Pont Method" of flame spraying, coating thickness, testing for porosity, and patching. Data are given on powders available, their cost, the result of corrosion tests on the coatings.

An Attachment to its "Scotchman" chemical spreader permits metering the recommended amount of rust-inhibiting Banox into salt being spread to melt ice and snow, Tarrant Manufacturing Co., Saratoga Spring, N. Y., announces.

Reliance Steel Co., 2068 E. 37th St.,

Los Angeles, Cal., will warehouse its magnesium wrought products, Dow Chemical Co., Midland, Mich., announces. The West Coast was selected for the first of a planned nation-wide designation of warehouses by the Michigan firm because of its distance from manufacturing centers.

Desk Sized "Before and After" samples of pipe of which half has been cleaned by its "Roto-Grit-Blast" method and the other half left as-milled, are offered by Hill, Hubbell and Co., 3091 Mayfield Road, Cleveland 18, Ohio. The 4-inch samples were made available after repeated requests for them were made by corrosion engineers, the company reports.

To cut down CORROSION in storage tanks



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Corrosion is expensive, it's a bother, it may be dangerous—and all three factors are involved when you have to replace corroded roof plates on fixed roof tanks. Cut down this corrosion by equipping your tanks with Horton Floating Roofs. As the view above shows, these roofs float directly on the surface of the liquid in the tank. Since there is no vapor space under the roof, the corrosion which would take place if air were present is eliminated. These roofs are available in the following designs to meet a wide range of storage requirements:

- Horton DOUBLE-DECK Floating Roof
- Horton PONTOON Floating Roof
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Chicago 4	2119 McCormick Building	Philadelphia 3	1661-1700 Walnut Street Building
Cleveland 15	2248 Guildhall Building	Salt Lake City 4	563 West 17th South Street
Detroit 26	1561 Lafayette Building	San Francisco 11	1272-22 Battery Street Building
Havana	402 Abreu Building	Seattle 1	1363 Henry Building
		Tulsa 3	1640 Hunt Building

Plants in: BIRMINGHAM, CHICAGO, SALT LAKE CITY, and GREENVILLE, PA.

PERSONALS

T. H. Caldwell, Jr., formerly manager of die casting sales for the magnesium division, Dow Chemical Co., has joined the firm's Atlanta, Ga. sales staff.

Wayne D. Staley, formerly New York district manager for the Duriron Co. has been named general sales manager and will be located at the home office, Dayton, Ohio. **R. F. Sharpe**, formerly manager of the Philadelphia office has been appointed New York District manager and **Ralph L. Watts**, formerly sales engineer in New York will be in charge of the Philadelphia office.

John S. (Jack) Talbot, development engineer for Dowell, Inc., at Alice, Texas has been named district sales engineer and transferred to the Houston district office. **Tom J. Tighe**, service engineer at Houma, La. has been promoted to sales engineer at Victoria, Texas and **Joe P. Moran**, Victoria Sales Engineer, has been transferred to Alice.

H. P. Fogle has joined Standard Pipe- protection, Inc. St. Louis, Mo. as manager of sales for the Southwest with headquarters at Houston, Texas.

L. B. Wilson, development engineer for Dowell, Inc. in New York City has been named general sales engineer, and the New York office placed under the General Sales Department in Tulsa, Okla.

Hugh W. Paul has joined Glass Fibers, Inc. Waterville, Ohio as special assistant to the president.

Greswold Van Dyke has been appointed executive director of Stainless Steel Producers-American Iron and Steel Institute.

T. G. Seal has been elected a vice president of Ebasco Services Incorporated.

Scheduled to be present at the Dowell Incorporated booth during the 1950 NACE Conference in St. Louis are **R. L. Featherly**, Saginaw, Mich.; **A. F. Vogler**, Lafayette, La.; **R. C. Robson**, Norman, Okla.; **S. A. Huckleberry**, Corpus Christi, Texas and **W. M. Zingg**, St. Louis.

Arthur Schwarz has been named vice-president in charge of sales of the Nooter Corporation, St. Louis, Mo.

Ralph M. Hunter, manager of the Electrochemical Division of the Dow Chemical Co. was presented with the honorary degree of doctor of engineering by the Case Institute of Technology on January 28, 1950.

J. M. Trissal, an NACE member for several years, and chairman of the 1949 Transportation Industry Symposium at Cincinnati has been appointed assistant chief engineer of Illinois Central Railroad with headquarters in Chicago, effective February 1.

Jay R. James, formerly with Dow Chemical Company, Houston and with

more than ten years of service with Dow has been put in charge of Cathodic Protection Service Tulsa office, 314 Thompson Bldg., Tulsa, Oklahoma.

Jack Harris has been named sales- manager for the Cameron Iron Works, Inc. LP Valve Division, a new division of the company, to market its new line of lift plug valves.

Francis Coryell, director of research, Interstate Pipe Line Company, Tulsa, co-author of the paper, "The Use of Ammonia in Control of Vapor Zone Corrosion," presented before the Dallas regional meeting in October, 1949, published in CORROSION in the February, 1950, issue, died January 6.

MEETINGS

March 26-30—117th National Meeting Houston Section, American Chemical Society, Shamrock Hotel, Houston, Texas.

April 11-12—American Zinc Institute annual meeting, Hotel Statler, St. Louis, Mo.

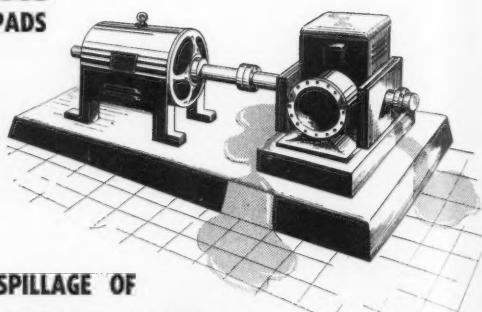
April 16-18—American Society of Lubrication Engineers, 6th Annual Convention, Bellevue-Stratford Hotel, Philadelphia, Pa.

April 25-26—Metal Powder Association 6th annual meeting, Book-Cadillac Hotel, Detroit, Mich.

POSITIVE PROTECTION FOR CONCRETE PUMP-PADS

ATLAS ALKALOY 550 COATING SOLVES THE PROBLEM

"Alkaloy 550" sets through chemical change into a superior corrosion resistant finish . . . a finish as hard as tile. Write us at 11 Walnut St. Mertztown, Penna., for Bulletin 7-1. . . . No obligation.



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CORROSIVE MATERIALS
ON CONCRETE PUMP-PADS PRESENTS
A SERIOUS MAINTENANCE PROBLEM**



THE ATLAS MINERAL PRODUCTS COMPANY

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NEW AND REINSTATED

MEMBERS

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NEW AND REINSTATED MEMBERS

(Changes Through January 27, 1950)

CALIFORNIA

FORD, CHARLES D., 1713 S. California Street, Monrovia, California.
MC CONNELL, FRED M., Koppers Co., Inc., 727 E. Gage Ave., Los Angeles 1, California.
PICKUP, LESTER R., Southern California Gas Co., 1700 Santa Fe Ave., Los Angeles, California.

WASHINGTON, D. C.

THOMPSON, JOHN G., National Bureau of Standards, Washington 25, D. C.

ILLINOIS

BUCKLEY, FRED S., The Flood Company P. O. Box 85, Des Plaines, Illinois.
KENNEDY, CARL M., Central Illinois Public Service Co., Room 1327—Illinois Bldg., 6th and Adams, Springfield, Illinois.
RYDELL, ROBERT G., Electro Rust-Proofing Corp., 1229 W. Washington, Chicago, Illinois.
SHELDahl, DAVID B., Sinclair Refining Co., 400 East Sibley Blvd., Harvey, Illinois.
SMITH, ROBERT J., Commonwealth Edison Co., 72 West Adams—Room 818, Chicago, Illinois.
WIELAND, WARREN E., Plastic Lining Corp., 914 South Wabash Ave., Chicago 5, Illinois.
WITHERS, FRANK P., Withers & Ropke, engineers, 2400 West Madison St., Chicago 12, Illinois.

INDIANA

FORT, GEORGE A., Carnegie-Illinois Steel Corp., Gary Works, Mail Sta. 11-1, Coke Plant, Gary, Indiana.
MORRISON, D. B., Carnegie-Illinois Steel Corp., Gary Steel Works, Gary, Indiana.

LOUISIANA

BARR, CLIFFORD L., Shell Oil Company, Richards Bldg., New Orleans, Louisiana.

MARYLAND

VON LOSSBERG, LEWIS G., c/o Sheppard T. Powell, Cons. Chem. Engr., 330 North Charles, Baltimore 1, Maryland.

MICHIGAN

BOYLAN, JAMES A., Parker Rust Proof Company, 2177 E. Milwaukee Avenue, Detroit, Michigan.
FEIDELMAN, HOWARD W., Chief Engineer, Morton Salt Company, Manistee, Michigan.

MISSOURI

CUMMINS, FRANK M., Standard Pipeprotection, Inc., 3000 Brentwood Avenue, St. Louis, Missouri.

NEBRASKA

ALLBRIGHT, RICHARD T., Omaha Public Power District, 17th and Harney Streets, Omaha, Nebraska.
BLISH, ERVIN R., Northern Natural Gas Company, Aquila Court Bldg., Omaha, Nebraska.

NEW JERSEY

AYRES, ALBERT L., New Jersey Bell Tel. Co., 281 Washington Street, 4th Floor, Newark 2, New Jersey.
CLOTES, WILLIAM P., National Lead Co., Titanium Div., P. O. Box 58, South Amboy, New Jersey.
COHEN, BENJAMIN J., J. I. Hass Co., Inc., 149 Montgomery, Jersey City, N. J.
NORTHPUP, M. S., Standard Oil Development Co., Esso Engineering Dept., Materials Laboratory Div., P. O. Box 121, Linden, New Jersey.

NEW YORK

BUENOSOD, A. C., Buensod-Stacey, Inc., 60 East 42nd Street, New York 17, New York.
COPLEY, JAMES S., National Carbon Co., Inc., 292 Madison Avenue, New York 17, New York.
DECK, HERBERT W., Long Island Lighting Co., 250 Old Country Road, Mineola, N. Y.
DREYMAN, EDGAR W., Kirkaldy System, Inc., 425 Hamilton Avenue, Brooklyn 32, N. Y.

NACE NEWS

GOODYEAR, MARK, Houghton Laboratories, Inc., 322 Bush Street, Olean, N. Y.
LAWTON, LEDRA M., Harrison Radiator Div., General Motors Corp., Washburn, Lockport, N. Y.

OHIO

ELLERBRAKE, EARL G., Sohio Pipe Line Co., 1738-A Midland Bldg., Cleveland 15, Ohio.
FRIEDL, BURT, Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio.
TRIPLER, ARCH B., JR., Battelle Memorial Institute, 505 King Avenue, Columbus 1, Ohio.

OKLAHOMA

STEWART, FRED W., Anode Engineering Co., 703 S. Richmond, P. O. Box 3355, Tulsa, Oklahoma.

PENNSYLVANIA

CIBULA, HENRY J., Koppers Company, Inc., Tar Products Div., Chamber of Commerce Bldg., Pittsburgh, Pa.
GLIDDEN, WILLIAM E., W. E. Glidden, Berwyn, Pa.
ROBERTS, JOHN K., J. K. Roberts Co., 416 Park Bldg., Pgh. (22) Pittsburgh, Pa.
SCHLOSSBERG, LOUIS, Quaker Chemical Products Corp., Conshohocken, Pa.

TENNESSEE

DEQUINE, LOUIS E., JR., American Bemberg, Elizabethton, Tennessee.

TEXAS

ALLEN, EDWARD R., Jr., Humble Pipe Line Co., P. O. Drawer 2220, Houston 1, Texas.
BARBE, LOUIE J., Jr., Humble Pipe Line Co., P. O. Drawer 2220, Houston 1, Texas.
BUTLER, JAMES H., Rosson-Richards Company, P. O. Box 908, Corpus Christi, Texas.
DORR, FRANK I., JR., United Gas Corp., P. O. Box 2628, Houston, Texas.
GERLOVICH, C. LEWIS, 122 Sunflower, Houston 4, Texas.
HALL, GEORGE D., Thornhill-Craver Co., Inc., P. O. Box 1184, Houston, Texas.
HAPP, CHARLES R., Gulf Oil Corporation, Port Arthur, Texas.
JOHNSON, ROBERT T., Ethyl-Dow Chemical Company, Freeport, Texas.
KELLY, WARNER M., Otis Pressure Control, Inc., 6705 Navigation, Houston, Texas.
KLEESPIES, HENRY S., JR., Gulf Oil Corp., 7th St. Road, Port Arthur, Texas.
KRCH, MILFORD F., National Lead Company, Baroid Sales Div., City National Bank, Houston, Texas.
MENEPEE, WM. F., 1915 8th Street, Wichita Falls, Texas.
MORGAN, ZANE V., Texas Acidizers, Inc., Box 47, Seguin, Texas.
MURPHY, G. J. W., The Texas Company, P. O. Box 425, Bellaire, Texas.

SCHUELER, ROBERT C., Celanese Corporation of America, P. O. Box 148, Bishop, Texas.
VIERLING, WM., Tin Processing Corporation, P. O. Box 1461, Texas City, Texas.
ZARUBA, RICHARD S., 4710 Clay, Houston 3, Texas.

UTAH

ANDERSON, JOHN S., Utah Power and Light Co., Rm. 203, Kearns Bldg., Salt Lake City, Utah.
COX, JOHN W., 1993 S. 17th E. Street, Salt Lake City, Utah.
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MAXENT, LACLEDE & CO., New Orleans fur traders, established the first permanent settlement on the site of St. Louis in 1764 when 13-year-old Auguste Chouteau and a party of workmen were sent to lay out five streets on the riverfront. These five streets formed the fur trading post which in five years made the "Village of St. Louis" the fur trading center of the West—a title still claimed by the modern city.

Following the Revolutionary War with England in the 1790's St. Louis boomed as a center of river traffic. Flat boatmen who carried the fur and produce of the Missouri valley fought a running battle down to New Orleans with murderous river pirates, until they finally combined their brawn to "purge" the river. When Napoleon sold the Louisiana Territory to the United States in 1803 the vast migration that settled the West began, with St. Louis a gateway for many of the wagon trains. Tumultuous scenes were enacted on the streets, teeming with emigrants, free-

booters, gamblers, explorers and political and religious rebels.

Shortly after August 2, 1817, the Zebulon M. Pike, first steamboat to reach St. Louis, puffed its way up from Louisville. A spurt of prosperity accompanied the rapid development of steamboat traffic on the Mississippi and Missouri. By 1880 the city's population was 350,000.

Between 1832 and 1850 there was a sustained migration of German professional men and scholars who were dissatisfied with conditions in their homeland. These settlers brought to the community a new interest in education, art and industry which contributed to its development.

In the 19th century, featured by the development of railway traffic, and interrupted only briefly by the Civil War, in which St. Louis went into the conflict on the side of the North, the city continued to grow, principally industrially.

The 20th century saw the storied Louisiana Purchase Exposition which brought many benefits and assets enjoyed by the city to this day.

31 Papers, Two Discussions Scheduled on '50 Technical Program

A revised schedule of papers to be presented during the technical program at the 1950 St. Louis Conference, corrected through February 16 is listed hereunder:

TUESDAY AFTERNOON, APRIL 4

Corrosion Principles Symposium Paper No.

- 1 "The Role of Polarization in Corrosion," by G. C. English, R. D. Williams and R. H. Brown, Chemical Metallurgy Div., Aluminum Research Laboratories, Aluminum Co. of America, New Kensington, Pa.
- 2 "The Influence of Stress on Corrosion," by Julius J. Harwood, Office of Naval Research, Washington, D. C.

WEDNESDAY MORNING,
APRIL 5

Chemical Industry Symposium

- 3 "The Behavior of The Chromium-Nickel Stainless Steels in Sulfuric Acid," by George C. Kiefer and William G. Renshaw, Allegheny Ludlum Steel Corp., Brackenridge, Pa.
- 4 "Corrosion of Metals by Insecticidal Solutions," by George S. Cook and Nancye Dickinson, Engineer

Research and Development Laboratories, Fort Belvoir, Va.

- 5 "Corrosion in Sulfur Production—The Use of an Alloy Protective Coating," by N. Hackerman and D. A. Shock, University of Texas, Austin.
- 6 "Corrosion of Metals in Fluorine and Hydrofluoric Acid," by G. C. Whitaker, Harshaw Chemical Co., Cleveland, Ohio.
- 7 "Design of Anode Systems for Cathodic Protection of Underground and Water Submerged Metallic Structures," by E. R. Shepard and Henry J. Graeser, Office of the Chief of Engineers, Department of the Army, Washington, D. C.
- 8 "A Study of Some Metals for Permanent Anodes in Water Tank Cathodic Protection Systems," by A. L. Kimmel, University of Florida, Gainesville, Fla.
- 9 "Cathodic Protection of an Active Ship in Sea Water," by G. L. Christie, Naval Research Establishment, Halifax, Canada.
- 10 "The Performance of Magnesium Galvanic Anodes in Underground Service," by Oliver Osborn and H. A. Robinson, Dow Chemical Co., Midland, Mich.

AFTERNOON, APRIL 5

Oil and Gas Industry Symposium

- 11 "Corrosion in Condensate and High Pressure Sweet Oil Wells," by R. C. Buchan, Humble Oil & Refining Co., Houston, Texas.

- 12 "Corrosion Problems in the Modern By-Product Coke Plant," by C. F. Pogacar, Koppers Co., Pittsburgh, Pa., and E. A. Tice, The International Nickel Co., Inc., New York, N. Y.

- 13 "Corrosion Experienced on a New Crude Distillation Unit at Port Arthur Refinery of Gulf Oil Corporation," by D. L. Burns, Gulf Oil Corp., Port Arthur, Texas.

- 14 "Selection of Organic Protective Coatings for Marine Use in Petroleum Production," by Jack P. Barrett, Stanolind Oil and Gas Co., Tulsa, Okla.

Transportation Industry Symposium

- 15 "Water-side Deterioration of Diesel Engine Cylinder Liners," by F. N. Speller, Consultant, Pittsburgh, Pa., and F. L. LaQue, The International Nickel Co., Inc., New York.

- 16 "Problems in Corrosion of the Railroads," by Ray McBriar, The Denver and Rio Grande Western Railroad, Denver, Colo.

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YOU ARE CORDIALLY
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(NO. 56) AND SEE A COMPLETE
LINE OF METER INSULATION . . .
and in particular, our **S.E.I. NUT**
THE SAFEST, CHEAPEST OF
ALL METER
INSULATION.

1950 N.A.C.E. CONFERENCE
JEFFERSON HOTEL — ST. LOUIS
APRIL 4, 5, 6, & 7

S E R V I C E E N G I N E E R S , I N C .

FIRST NATIONAL BANK BLDG.

FORT WORTH, TEXAS

17 "Corrosion Problems Related to Air Transport Aircraft," by Otto E. Kirchner, American Airlines, Tulsa, Okla., and Fred M. Morris, American Airlines, LaGuardia Field, New York, N. Y.

MORNING, APRIL 6

Protective Coatings Symposium

18 "Surface Preparation Values and Sandblasting Economics," by A. J. Liebman, Dravo Corp., Pittsburgh, Pa.

19 "Flame Sprayed Plastic Coatings," by Bernard Goldberg, Schori Process Corp., Long Island City, N. Y.

20 "A Progress Report on the Use of Cathodic Protection in Conjunction with Paint Coatings," by William L. Crosby, Consolidated Edison Co. of New York, New York.

(Prepared Discussions of Preceding Papers)

Fresh and Salt Water Corrosion Symposium

21 "Ohio River Division Corrosion Problems," by J. A. Davenport, Corps of Engineers, Cincinnati, Ohio.

22 "Comparative Corrosion Resistance of Killed and Rimmed Steel Pipe in Sea Water," by V. V. Kendall, National Tube Co., Pittsburgh, Pa.

23 "Electrochemical Behavior of Zinc and Steel in Aqueous Media—Part II," by R. B. Hoxeng, Case Institute of Technology, Cleveland, Ohio.

24 "Cathodic Protection of Fourteen Offshore Drilling Platforms," by E. P. and G. L. Doremus, Cathodic Protection Service, Houston, Texas.

25 "Potentials Set Up by Thermal Gradients in Iron Immersed in NaCl Solutions," by H. H. Uhlig, Corrosion Laboratory, Massachusetts Institute of Technology, Cambridge, Mass., and Oscar F. Noss, Jr., Union Oil Co. of California, Wilmington, Calif.

AFTERNOON, APRIL 6

Food Industry Symposium

26 "Corrosion Resistant Equipment for the Corn Refining Industry," by R. W. Flournoy, Corn Products Refining Co., Argo, Ill.

27 "Metals Used in the Dairy Industry," by C. Y. McCown and G. W. Putnam, The Creamery Package Manufacturing Co., Chicago, Ill.

28 "Some Aspects of the Corrosion of Tin Plate by Prunes," by V. W. Vaurio, Carnegie-Illinois Steel Corp., Pittsburgh, Pa.

Pipe Line Corrosion Symposium

29 "Surface Potential Method of Corrosion Survey on Pipe Lines," by O. W. Wade, Great Lakes Pipe Line Co., Independence, Kan.

30 "Internal and External Corrosion Prevention in a Products Pipe Line," by S. S. Smith, E. H. Rush and W. J. Curry, Shell Oil Co., New York, N. Y.

1950 ST. LOUIS CONFERENCE

21

31 "Training Program for Corrosion Technicians," by James R. Cowles, Oklahoma Natural Gas Co., Tulsa, Okla.

MORNING, APRIL 7

Pipe Line Protection Round Table and General Corrosion Problems Round Table, both consisting of extemporaneous discussions, will be held simultaneously.

Papers presented at sessions of NACE are submitted for review to the association's editorial review committee for consideration as material to be published in the official publication of the association, CORROSION. Ordinarily technical papers are not preprinted and

complete copies are not available for inspection or distribution except as published in the official publication.

The association furnishes in advance of publication extensive abstracts of the papers, and when preprints are available, authorizes publication of portions of manuscripts not to exceed one-third of the total paper. Permission to reprint after publication in CORROSION usually is granted to responsible publications and others on request, provided such reprinting gives full credit to prior publication. Excerpts from manuscripts and abstracts may be published with full credit to presentation before NACE.

Papers will be available for inspection at St. Louis as preprints will not be available.

When You Attend the 1950 N.A.C.E. Convention...



See Our Display of...

- WmSEAL Casing Bushings
- Concentric Support Insulators
- Williamson Pipe Line Pigs
- Automatic Scraper Signal
- Hillco Tapping Machines
- M-Scope Combined Pipe Finder and Leak Detector

BOOTH No. 65

**THE PIG WITH THE POKE
CLEANS PIPE LINES**

T. D. Williamson, Inc.

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Discussion Procedure For Conference is Outlined

Procedure for collection and processing of discussions and remarks made during presentation of technical papers at symposia of the 1950 NACE Conference in St. Louis was defined as follows by Dr. Aaron Wachter, technical program chairman:

Collection of Discussions

Forms will be provided by NACE for distribution to persons attending the technical sessions on which places for the following information are provided:

1. Number of paper.
2. Name of person making the remarks.

3. Full mailing address.
4. Brief summary of content of remarks or discussion.

An effort will be made to give each person making a comment on a paper copies of this form, to be called "Discussion Record" with the request that he fill it in and deposit it in boxes provided in the discussion room or elsewhere in the conference area. The forms also may be mailed to NACE.

Collection of Remarks

After the close of the conference all remarks forms will be collected by Central Office personnel and the information provided on the forms will be used to solicit by mail written versions of the remarks.

This will be accomplished in approximately the following manner:

1. Names and addresses will be verified.

2. Triplicate copies of a "request for written remarks" will be sent to each person from whom a "Discussion Record" is received.

3. The person to whom these requests for written remarks are addressed will be asked to write his comments, returning duplicate copies to NACE and keeping one for himself.

4. One copy of each written remark so received will be sent to the author of the paper to which it refers. The author will then have the opportunity to comment on the remarks.

5. Written remarks, plus author's comments then are sent to Dr. Ivy Parker, editor of Corrosion for review.

6. Following approval for publication the remarks plus author's comments will be published in the earliest possible issue if the paper to which they refer already has been published. If the paper to which they refer has not been published, they will be added to the manuscript's end when the article is approved for publication and published at the same time the article is published.

7. Comments published at times other than that of the article to which they refer will be indexed with the article in the annual index published in December.

Symposia chairmen also will be asked to assign to some one the duty of filling out a "Discussion Record" form for each person making a remark in order to keep a record of those who fail to fill in the form themselves.

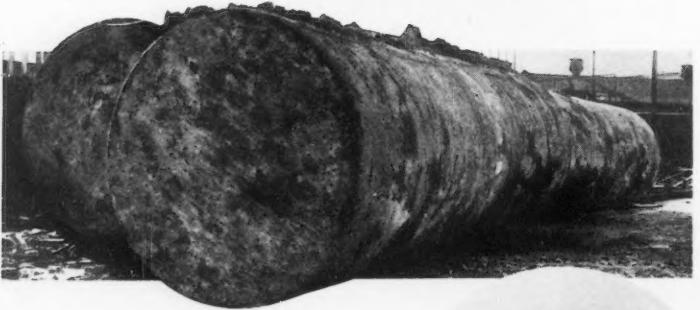
This procedure has several outstanding advantages, conference officials believe.

1. It gives every person making a remark the opportunity to review his comment and make additions or changes where necessary.

2. It gives authors the opportunity to reply in detail where necessary.

19 Years Underground...

PROTECTED BY AN INSUL-MASTIC COATING



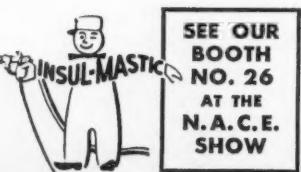
After being buried for nineteen years, these 10,000 gallon tanks were dug up and moved to a new location where—still fit for duty—they were placed in service again. An Insul-Mastic coating had protected them from rust and corrosion during all those years underground.

The Chicago Testing Laboratory examined the tanks and stated, "The tanks were found to be in an excellent state of preservation with the protective coating still intact. It is very evident from a critical examination of these tanks that the protective coating on them would have continued to function for many additional years."

During these nineteen years Insul-Mastic coatings have been improved, and are today superior to those used on the tanks depicted. Protective coatings that render such service warrant your investigation, regardless of the nature of your protection problems. Consult us at no obligation.



Waterfilled hole where tanks once rested shows poor drainage of damp ground, once swampland.



Insul-Mastic Corporation OF AMERICA

OLIVER BUILDING • PITTSBURGH 22, PENNSYLVANIA

Two Discussion Sessions Are Scheduled April 7

Procedure for the collection and publication of discussions occurring during the General Corrosion Problems Round Table Discussions scheduled for the morning of April 7 have been given as follows by F. L. LaQue, chairman:

Specialists in several fields of corrosion will be present to handle questions in their spheres of knowledge. These specialists will be asked to record the questions and answers, but not the names of questioners or answerers (unless specifically requested to do so) for subsequent arrangement into a narrative report to be submitted for publication in CORROSION.

Both Mr. LaQue and Mr. F. J. McElhatton, who will be chairman of the Pipe Line Protection Round Table now are accepting questions by mail to be put before the meeting. Both questions and answers from the floor are solicited and anticipated.

Persons who wish to do so may submit in writing now questions they would like to have answered to Mr. LaQue, Corrosion Engineering Section, The International Nickel Co., Inc., 67 Wall Street, New York, N. Y., or to Mr. McElhatton, Panhandle Eastern Pipe Line Co., Kansas City, Mo.

Majority of Committee Meetings to Be April 3

Designating Monday, April 3, the day immediately preceding the official opening of the 1950 NACE Conference in St. Louis as a day for meetings of principal committees will help in eliminating conflicts of interest among committee members who wish also to participate in some of the other activities of the conference which will be virtually continuous beginning Tuesday morning. A survey of preferences by general NACE, Technical Practices and other committee chairmen is under way by Central Office NACE to establish the final meeting schedule. In view of the necessity for avoiding conflicts, it is probable that a final schedule of meetings may not be available for publication prior to the official conference program.

In view of the likelihood some conflicts may develop among committees whose personnel may be the same, it is probable some committee meetings will be scheduled on other days during the conference as well.

However, it is the consensus that allocation of a full day to committee meetings will be beneficial in clearing the way for fuller participation in other conference activities by members.

Tentative Agenda Given For Inter-Society Group

Agenda for the meeting of the Inter-Society Corrosion Committee to be held at Hotel Jefferson, St. Louis, during the sixth annual NACE conference has been outlined tentatively by Dr. H. H. Uhlig, chairman, as follows:

- 1) A report on revised corrosion definitions, and a unified code for reporting corrosion damage; 2) Discussion of further plans for assembling a bank of corrosion specimens available to the public as standards in corrosion tests; 3) Report on liaison with foreign technical societies; 4) Discussion of short survey courses on corrosion.

The committee, which has been assigned the activities originally handled by the American Coordinating Committee on Corrosion, now numbers 30 co-operating technical societies and government laboratories among its members. Membership of the committee is 48. Vice-chairman is Sam Tour, of Sam Tour, Inc., and the secretary is A. B. Campbell, who also is secretary of NACE.

NACE Booth Will Give Publications Information

An information and exhibit booth staffed by NACE personnel will be located at the south end of the Hotel Jefferson mezzanine. It is located on the same floor as the exhibition and is readily accessible from principal entrances of the hotel to those seeking information about the conference, NACE or its activities.

1950 ST. LOUIS CONFERENCE

Brochures and pamphlets about the association will be available. All interested in membership are invited to visit the booth.

Copies of NACE publications, including CORROSION, Cathodic Protection—A Symposium, Control of Pipe Line Corrosion, and other books, reports and reprints will be available for inspection. Orders for these publications will be taken at the booth. Space limitations prevent stocking for direct sales. Orders for NACE lapel pins will be taken and applications for membership will be accepted.

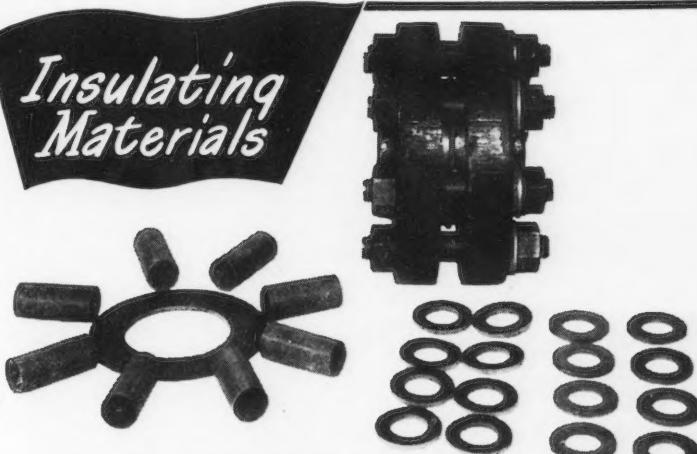
Available also at this booth to representatives of the press will be printed abstracts of technical papers. Central Office personnel present will be able to assist in the preparation of news stories about the conference.

Abstracts of Technical Papers Will Be Issued

Abstracts of technical papers to be presented during the 1950 Conference at St. Louis will be made available to the press on much the same basis as in former years. Central Office expects to be able to reproduce all, or nearly all of the abstracts of papers scheduled this year. These will be published and will be available at the conference.

Restrictions on the publication of technical papers by periodicals before publication in CORROSION are that not more than one-third of an article may be extracted for use by other periodicals. Copies of papers to be presented at St. Louis will be available for inspection by members of the visiting press, according to plans now being made.

Insulating Materials



for PIPE NIPPLES and PIPELINE FLANGES

WRITE FOR VALUABLE, NEW BULLETIN

For a period of 11 years the Nelson Electric Manufacturing Company has been furnishing Phenolic Insulating Materials for pipe nipples and the insulation of pipeline flanges. We introduced the use of thin-wall tubing sleeves for insulating the studs in standard flanges, without requiring re-drilling of the flange and providing smaller studs. We now offer flange insulation, packaged for immediate shipment on the more common sizes.

Write for new, 10-page bulletin which describes our Insulating Materials.

You are cordially invited to
See Our Equipment Exhibit at the NACE Conference

NELSON Electric MANUFACTURING CO.

217 N. Detroit St.

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Provisions for Registration Are Outlined

Registration for the 1950 conference and exhibition in St. Louis will take place on the mezzanine floor of the Jefferson Hotel adjacent to the elevators. Registration cards, identification badges and tickets for the annual banquet will be available at the desk. Registration hours have been set tentatively to be 8 a. m. to 5 p. m. daily, Monday, April 3, through Friday, April 7.

No provision has been made for pre-registration.

Registration cards will include each registrant's name, company affiliation, address and membership status. Badges will be issued upon presentation of completed cards which will permit attendance at any technical session and inspection of any exhibit and attendance at the Tuesday night Fellowship Hour.

Tickets for the Thursday night banquet will be in addition to the registration fee.

Slide Projectors Readied

Slide projection equipment provided for use during technical sessions at the 1950 St. Louis Conference will consist of standard 3½ x 4 projectors and 8-foot x 8-foot screens for both the Gold Room at the Jefferson Hotel and the Christ

Church Cathedral auditorium. Both will have 1000-watt lamps. A standby 1000-watt 2-inch x 2-inch projector will be available if needed by anyone. All projectors will have blowers and will handle either color or black and white slides.

This equipment has been arranged for by Mr. W. H. Keller of Johns-Manville Corp., St. Louis.

59

Time Schedule Is Given For Major Activities

The following time schedule for various events during the 1950 conference has been set tentatively:

Exhibit hours: Tuesday and Thursday, 10 a. m. to 5:30 p. m.; Wednesday, 10 a. m. to 6:30 p. m.; Friday, 10 a. m. to 3 p. m.

Technical sessions: Tuesday through Thursday, 9 to 12 a. m. and 2:30 to 5 p. m.; Friday, 9 to 12 a. m.

Fellowship Hour: Tuesday, 6 to 7 p. m., Gold Room.

Annual Banquet: Thursday, 7 p. m., Gold Room.

No final schedule on committee meetings will be available before publication of the official program.

Correlating Committee Meeting Set for April 4

The Correlating Committee on Cathodic Protection will meet at 9 a. m. April 4 during the NACE Conference. H. H. Anderson, Shell Pipe Line Corp., Houston, is chairman, and J. M. Standing, American Telephone and Telegraph Co., New York, is chairman of Subcommittee 3. Place of meeting will be posted on the Jefferson Hotel bulletin board.

PIPE PROTECTION

(in a protected package)

Ruberoid introduces an exclusive MOISTURE-RESISTANT package

Mud and rain can make a mess out of an ordinary package of pipe line felt. The weather hazards of field-wrapping jobs are very substantially reduced by this new package which is constructed of waterproofed kraft and a special edging seal. It's an exclusive Ruberoid development—available at no extra cost when requested on your orders.

Inside the package you find the finest felt you can possibly specify for protection of pipe line coatings. Imperial asbestos felt is acclaimed by users for its long-fibered strength (asbestos—not wood pulp) and its long-lived efficiency in protecting against electrolysis, soil distortion and settlement.



National Distributor

S. D. DAY COMPANY

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"Serving All Pipe Lines"

Visit Our Booth #29

Hotel Jefferson, St. Louis

April 4 to 7

BOOK REVIEWS

FRENCH FINE AND SPECIAL STEELS

(Les Aciers Fins et Spéciaux Français) (In French). Published by Chambres Syndicale des Producteurs D'Aciers Fins et Spéciaux, 5, Rue Paul Cézanne, Paris (viii*). 332 Pages, 6x9, cloth bound, French francs 770, obtainable from SPAS, 12 rue de Madrid, Paris.

Prominent technicians in the French Fine and Special Steel Producers' Association have combined their talents to produce a thumb-indexed volume which gives detailed information about the composition and principal service characteristics of steels produced by the 42 members of this association. The book is designed for the steel user's convenience in selecting a material which exactly meets service expected, and defines the characteristics of the special steels so a rational selection may be made.

Among other things the volume includes a small technical dictionary in which are listed in tabular form equivalent technical terms in French, German, English and Spanish.

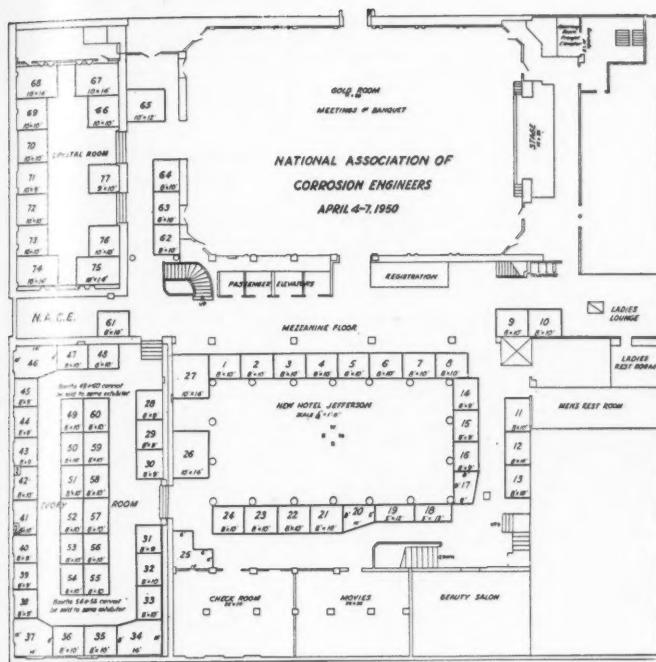
RUBEROID PIPE LINE FELTS

The RUBEROID Co.

EXECUTIVE OFFICES: 500 FIFTH AVE., NEW YORK 18, N. Y.

PRE-VIEW OF 1950 CONFERENCE EXHIBIT FEATURES

59 Exhibitors Plan to Display Products at St. Louis Meeting



Arrangement of exhibit booths at Hotel Jefferson, St. Louis, Mo., for the 1950 NACE conference, April 4-7.

1950 EXHIBITORS AND BOOTH NUMBERS

1-2 Dowell Incorporated, Tulsa, Okla.
 3 Lexington Supply Co., Cleveland, Ohio
 4 Midwestern Engine & Equipment Co., Inc., Tulsa, Okla.
 5-6 Owens Corning Fiberglas Corp., Toledo, Ohio
 7-8 Westinghouse Electric Corp., Pittsburgh, Pa.
 9 Duriron Co., Inc., Dayton, Ohio
 10 Rust-Oleum Corp., Evanston, Ill.
 11-12 Cathodic Servicing Co., Oklahoma City, Okla.
 13 Plastic Lining Corp., Chicago, Ill.
 14-15 U. S. Stoneware Co., Akron, Ohio
 16 Sarah Lined Pipe Co., Detroit, Mich.
 17 Cameron Iron Works, Inc., Houston, Texas
 18-19 Pfaudler Co., Rochester, N. Y.
 20-21 Magnaflux Corp., Chicago, Ill.
 22 Heil Process Equipment Corp., Cleveland, Ohio
 23 Hills-McCanna Co., Chicago, Ill.
 24 Oklahoma Glass Fiber Corp., Tulsa, Okla.
 25 Cathodic Protection Service, Houston, Texas
 26 Insul-Mastic Corporation of America, Pittsburgh, Pa.
 27 Johns-Manville Sales Corp., New York, N. Y.
 28 Harco Corp., Cleveland, Ohio
 29 Ruberoid Co., Pipe Line Felt Dept., New York, N. Y.
 30 Nelson Electric Manufacturing Co., Tulsa, Okla.
 31 Grip-Tite Manufacturing Co., Marshall, Texas
 32 Philip Carey Manufacturing Co., Cincinnati, Ohio
 33 Natasco Co., Tulsa, Okla.
 34 Plastic Engineering & Sales Corp., Fort Worth, Texas
 35-36 The Barrett Div., Allied Chemical & Dye Corp., New York, N. Y.
 37 Lebanon Steel Foundry, Lebanon, Pa.
 38 Game Industries, Inc., New York, N. Y.
 39-40 Pipeline Maintenance Corp., Tulsa, Okla.
 41-42 International Nickel Co., Inc., New York, N. Y.

43 Tinker & Raso, San Gabriel, Calif.
 44 Royston Laboratories, Inc., Blawnox, Pa.
 45 Standard Pipeprotection, Inc., St. Louis, Mo.
 46 Crutelote-Rolfs-Cummings, Inc., Tulsa-Houston
 47 Trelolite Co., Webster Groves, Mo.
 48 Federated Metals Div., American Smelting & Refining Co., New York, N. Y.
 49-50 Dearborn Chemical Co., Chicago, Ill.
 51-52 Pittsburgh Coke & Chemical Co., Pittsburgh, Pa.
 53-54 National Lead Co., Pigments Division, New York, N. Y.
 55 National Lead Co., Metals Div., New York, N. Y.
 56 Service Engineers, Inc., Fort Worth, Texas
 57 Hill, Hubbell & Co. Div., General Paint Corp., Cleveland, Ohio
 58-59 Pipe Line Service Corp., Franklin Park, Ill.
 60 The Tapecoat Co., Evanston, Ill.
 61 Dresser Manufacturing Div., Bradford, Pa.
 62 Amercoat Corp., Chicago, Ill.
 63 Electro Rust-Proofing Corp., Belleville, N. J.
 64 Good-All Electric Manufacturing Co., Ogallala, Neb.
 65 T. D. Williamson, Inc., Tulsa, Okla.
 66-67 Aluminum Company of America, Pittsburgh, Pa.
 68 M. J. Crose Manufacturing Co., Inc., Tulsa, Okla.
 69 Burgess-Parr Co., Freeport, Ill.
 70 National Carbon Div., Union Carbide & Carbon Corp., New York, N. Y.
 71-72 Koppers Co., Inc., Tar Products Div., Pittsburgh, Pa.
 73-74 Stearns Co., D. E., Shreveport, La.
 75 Perrault Brothers, Inc., Tulsa, Okla.
 76 Minnesota Mining & Manufacturing Co., St. Paul, Minn.
 77 Branson Instruments, Inc., Stamford, Conn.

Variety of Corrosion Mitigation Materials, Processes Included

The 77 booths of the Sixth Annual Exhibit of the National Association of Corrosion Engineers at Hotel Jefferson, April 4-7, 1950, have been taken by 59 organizations. This makes the 1950 exhibit the largest sponsored so far by the association.

Products to be shown come from and are applicable to a wide variety of industries and encompass numerous materials for corrosion-mitigation applications, instruments for testing corrosion control measures, for determining probable intensity of corrosion, and engineering and construction services of all kinds.

One of the principal advantages of an exhibit of the type sponsored by NACE is that it enables persons interested in new developments in the commercial field to personally see the materials and methods they believe may be useful to them, and to discuss their problems with men who are conversant with the characteristics of products and application of preventive measures.

A significant change from the arrangements in former years with respect to the conference exhibit is the provision for roughly 2½ hours at mid-day when persons who otherwise are occupied attending technical sessions may have the opportunity to visit the exhibit.

Plans likewise have been made to close the exhibit early enough on the last day of the conference so exhibitors may take down their displays during the afternoon.

Some exhibitors at the 1950 conference have taken the opportunity to describe the content of their displays. These descriptions begin on the next page.

All Exhibit Space At Conference Allocated

All exhibit space for the 1950 NACE Conference and Exhibition has been allocated. Exhibitors added to those previously published are:

Branson Instruments, Inc., Stamford, Conn.; Cameron Iron Works, Houston, Texas; M. J. Crose Mfg. Co., Tulsa, Okla.; GAMA Industries, New York, N. Y.; Heil Process Equipment Corp., Cleveland, Ohio; Hills McCanna Co., Chicago, Ill.; Plastic Lining Corp., Chicago, Ill. and Pfaudler Co., Rochester, N. Y.

The 77 booths are to be used by 59 organizations. This will be the largest exhibition sponsored so far by NACE.

DESCRIPTIONS OF SCHEDULED EXHIBITS AT ST. LOUIS

ALUMINUM CO. OF AMERICA
Booths 66-67

Seamless tubes with Alclad inside surfaces and welded tubes with both sides surfaced with Alclad, extended surface aluminum tubes, finned tubes and other examples of aluminum chemical equipment will be displayed by Aluminum Company of America, Pittsburgh, Pa.

Among the other items to be shown are bubble caps, tank roofs for sour crude oil, pipe and pipe line materials. The application of aluminum sheet as weather-proofing for thermal insulation, aluminum instrument tubing, aluminum soil anodes of both bare and packaged types, cast and extruded ribbon-type magnesium anodes for water tanks and high resistance soils also will be shown.

Manager of the Alcoa exhibit will be Ellis D. Verink, Jr., Head, Chemical Section, Development Division.

BRANSON INSTRUMENTS, INC.
Booth 77

"Audigage" and "Coatingage" thickness testers and the "Electronic Caliper" will be shown in operation on typical samples by Branson Instruments, Inc., Stamford, Conn. Visitors' specimens will be tested if desired.

Branson instruments test materials and thicknesses of coatings non-destructively. The Audigage, a portable, battery-operated instrument for field inspection, uses the ultrasonic resonance method of determining wall thicknesses for all kinds

of steel vessels from 1/16th inch to 12 inches thick, and also that of most other metals and some plastics. The instrument, of which about 200 are in use in refineries, chemical plants, utilities, pulp and steel mills and related industries, also is used to detect laminar flaws and hydrogen blistering.

Non-magnetic coatings on iron or steel are measured by the "Coatingage" a battery-operated, light-weight instrument for field inspections of plastics, glass and lead linings, etc. ranging from 0.0001-inch to 0.50-inch. Attachment of a moistened roller to the Coatingage permits testing coating for pinholes.

Metal wall thickness is measured by the "Electronic Caliper" an instrument most suitable for cast iron and applications where corrosion is extremely severe.

CAMERON IRON WORKS—
Booth 17

Cameron Non-Lubricated "LP" Valves, a product of Cameron Iron Works, Inc., Houston will be shown at this company's booth. The valves, culmination of ten years of research and development, have the principal advantages of plug and gate valves without the disadvantages of either, Jack Harris, LP Valve Division sales manager, who will be present at the booth, reports. The valves' most important single advantage is that it requires no lubrication either to ease operation or to effect a seal.

The operation permits application of

the lift-turn principle of operating the plug. Recognized advantages of this principle are combined with a separate replaceable seat.

Pilot models of the valve were put in service in 1943, and numerous subsequent tests with improved models, including service handling sulfuric and hydrofluoric acid, have been made.

Also scheduled to be present at the Cameron booth will be Ames Bliss, sales engineer.

CATHODIC PROTECTION SERVICE—Booth 25

A complete line of cathodic protection material and supplies will be shown at Cathodic Protection Service's booth. A sample of the new General Electric rectifier for cathodic protection, incorporating the wartime-developed oil immersed selenium stacks hermetically sealed in individual cans, will be on display. Dowell anodes, Cadwell welding equipment, insulating materials, National carbon anodes and numerous types of instruments will be shown.

Both Houston and Tulsa offices of the firm will be represented by engineers at the booth, the latter by Cathodic Protection Service's recently appointed representative, J. R. James.

DOWELL INCORPORATED
Booths 1-2

Magnesium anodes for cathodic protection of buried and submerged metal

THE FIRST
COMPLETE CORROSION MITIGATION
PRODUCT AND EQUIPMENT LINE
A ONE-CALL Service

We Invite Your Immediate Inquiry . . . Call . . . Write . . . Wire

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Our complete line offers the proper answer to your problem. A choice between all types of Anti-Corrosion Materials.

See the booths of the following manufacturers, whom we represent, at the Hotel Jefferson — April 4-7.

Manufacturer	Booth No.
OKLAHOMA GLASS FIBER CORP.	24
NELSON ELECTRIC COMPANY	30
GAMA INDUSTRIES, INC.	38
NATIONAL CARBON COMPANY	70
KOPPERS COMPANY	71-72
D. E. STEARNS COMPANY	73-74

March, 1950.

1950 CONFERENCE EXHIBIT

27

structures will be featured in the Dowell Incorporated exhibit.

How Dowell magnesium anodes aid in mitigating corrosion will be illustrated by display material, literature and sound-film.

Types of magnesium anodes and methods of application will be explained by attending Dowell engineers. Prepared cathodic protection units, Galvo-Paks and Galvo-Line will be included.

Five models of the bare, cast anodes ranging in weight from 17 to 60 pounds, each designed for a specific application but readily adaptable to unusual circumstances will be displayed along with Galvo-Pak units in two sizes of anodes together with a specially prepared, quick wetting bakfill in a permeable cloth sack, and Galvo-Line, a cored magnesium ribbon for underground installation with conventional cable-laying plows.

Representing Dowell at the show will be R. D. Shaw, general salesmanager; Guy Williams, assistant salesmanager; Yale W. Titterington, development engineer; P. N. Hardin, editor of "The Magnesium Anode" a technical publication and Chad J. Steward, advertising manager.

DURIORN COMPANY, INC.

Booth 9

Examples of Durco-engineered equipment, and rough castings from which much of the equipment is machined, the latter of interest because they are typical of the castings normally supplied by the company's foundries will be among the items on display at the exhibit of The Duriron Co., Inc., Dayton, Ohio.

Interesting examples of various kinds of corrosion will be included also.

Duriron engineers who specialize in corrosion problems will be on hand at the booth to discuss corrosion problems. Bulletin information fully describing the company's alloys and equipment will be available.

HEIL PROCESS EQUIPMENT CORP.

Booth 22

New chemical-proof plastic and rubber lining materials, new designs of impervious graphite heating devices, lined piping and material for lining tank cars, trucks and drums will be shown by Heil Process Equipment Corp., Cleveland, Ohio. The firm manufactures complete processing equipment, including vessels, linings, heat exchangers, process piping and exhaust ducts.

Chemical proof construction will be highlighted in the exhibit by: Plastic lined piping to handle mixed nitric and hydrofluoric acid fume exhausts, impervious graphite heating units, synthetic plastic sheet lining materials which have been applied to chlorine cells built by the firm, specimens of transportation facility linings, such as lead, rubber, Koroseal, Saran and Neoprene lined piping for conveying alkaline and acid solutions, including hydrochloric, sulfuric, chromic and nitric acids and their salts, phenolic material-lined process equipment.

Representatives at the booth will be C. E. Heil, president of the company, Kingsley Davey, H. H. Blouch and E. W. Vereeke.

HILL, HUBBELL & CO. DIV.,
GENERAL PAINT CO.—Booth 57

Modern methods used by Hill, Hubbell in cleaning and coating pipe at its Lorain and Girard, Ohio plants will be keynote of the General Paint Co., Hill Hubbell & Co., Division display. The booth will feature a large sample pipe, peeled to expose all coatings. It will help engineers visualize step-by-step the Hill, Hubbell process of pipe protection.

A news feature of the booth is the complete story of the "Roto-Grit-Blast" angular steel-grit blasting process used by the company. Samples of pipe showing surfaces before and after grit-blasting will be given away. Enlarged photographs will show pipe cleaning and coating operations under way at Hill, Hubbell plants. Among the company's engineers who will be present at the booth to discuss pipe wrapping and corrosion problems will be Milt Bowen.

INSUL-MASTIC CORP. OF
AMERICA—Booth 26

Photographs of storage tanks coated with Insul-Mastic which were buried in reclaimed swampland for 19 years will be shown at the exhibit of Insul-Mastic Corp., Pittsburgh, Pa. Chicago Testing Laboratory assured the owner of the tanks, which were removed to another location, the coating would serve for many more years underground.

Also to be shown will be the company's cork-impregnated coating, in a demonstration which shows how it retards heat loss and prevents condensation, in addition to preventing corrosion.

By test or by photographs the com-

GAMA INDUSTRIES, INC.

70 Pine St., New York 5, N. Y.

ANNOUNCE the manufacture of 15# Asbestos Pipe Line Felt made to AWWA Specifications.

A Felt available in standard sizes for travelling machine or mill or yard wrap. Saturant (tar or asphalt) depending on coating used.

A high purity Asbestos Felt with minimum organic materials.

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pany will show that most alkalis and acids have little or no deteriorating effect on Insul-Mastic.

The Insul-Mastic Vinyl system, an outgrowth of the method used by the company to coat planes and other fighting equipment for long-term storage is a flexible, durable plastic and mastic combination for protecting thermal insulation. It is designed to replace brittle cement, to keep insulation dry and prevent corrosion of the vessel underneath.

Representing the corporation at its booth will be Clifford Off, Jr., salesman; Harry E. Rapp, technical director; Abner Bagenstose, technical engineer and Robert H. Maloy, advertising manager.

JOHNS-MANVILLE SALES CORP.
Booth 27

Pipe line felts, Transite pressure pipe and Transite ducts, Marinite, Chemstone and corrugated Transite and also packings and gaskets will be displayed by Johns-Manville Sales Corp., New York City.

The pipe line felts, which provide a tough rot-proof shield against earth load, stress and corrosive soils, will have a prominent place. Applications for Transite pipe and ducts, and specially developed couplings for these pipes and ducts will be shown. The use of other materials manufactured by the company will be illustrated.

Suggestions as to best use and selection will be available from J-M representatives.

**NATIONAL CARBON DIVISION of
Union Carbide and Carbon Corp.**
Booth 70

"National" carbon and graphite ground anodes for cathodic protection, Karbate, impervious carbon and graphite, plate and tube and shell type heat exchangers, sectional cascade coolers, standard pipe, fittings, connections, valves and brick in standard shapes and sizes will be displayed by National Carbon Division of Union Carbide and Carbon Corp., New York City.

Karbate plate type heat exchangers, used for heating or cooling corrosive solutions, resist corrosion and withstand severe thermal shock. Efficient cooling of corrosive liquids and gases is possible with Karbate sectional cascade coolers, the company asserts. Liquid temperatures up to 170 degree C, at pressures up to 75 psi are practical, while minor changes in cooling water application permit using the coolers for gases well in excess of this temperature.

Representing National Carbon at the booth will be J. P. Oliver, W. W. Palmquist, H. L. Shepard, H. H. Frasch, Rolf Lindenhayn, Jr., and A. W. Wolff.

**NELSON ELECTRIC
MANUFACTURING CO.**
Booth 30

"NEMCO" selenium rectifiers for cathodic protection installations and insulating materials for pipe nipples and flanges will be among the materials shown by Nelson Electric Manufacturing Co., Tulsa, Oklahoma.

The company also will show pipe line

locators, the Pearson Electronic Coating Inspector, portable electronic voltmeter, Shepard Soil resistance meter, copper sulfate electrodes and other kinds of test equipment.

Representing the company at the booth will be H. A. Norberg, manager and John H. Elsloo, sales engineer.

PLASTIC LINING CORP.
Booth 30

Copolymer vinyl resins, development and application of which has brought the Plastic Lining Corp., Chicago, Ill., into practically every known field of corrosion, will be shown at the company's booth.

The company's copolymer vinyl series for industrial finishing work, introduced last year, has been extended for use in the container field. Information on this development, and other information developed during the firm's twelve years of work with copolymer vinyl resins will be available on request.

Present at the booth will be Warren Wieland and C. A. Van Natta.

ROYSTON LABORATORIES, INC.
Booth 44

Roskote resin products, based on the processing of Wurtzite pyrobitumines organosol, a colloidal hydrocarbon; clear and pigmented resin coatings, Roylec, styrene base, coatings and vehicles, Vinolac sealer for wood, Vinolic adhesive primer, Vinachrome wash primer and a variety of wax, water-proofing and inhibitive coatings for wood, steel and concrete will be shown by Royston Laboratories, Inc., Blawnox, Pa.

The Roskote resins, compounded into

Pipe Line Economy Begins ABOVE GROUND

Oklahoma Glass Fiber Reinforcement* not only helps provide positive protection for your pipe line against corrosion, but it affords definite economies in the wrapping process as well.

Oklahoma Glass Fiber Reinforcement helps you economize on your pipe line three ways:

1. By using 1200' rolls you eliminate $\frac{1}{3}$ of the shutdown time necessary with the 800' rolls.
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3. The uniform porosity and penetration of Oklahoma Glass Fiber Reinforcement adds materially to the life of the coating.

MAXIMUM POROSITY
SUPERIOR PICK-UP FACTOR
HIGHEST TENSILE STRENGTH
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This research and manufacturing organization will be represented at its booth by Dr. H. C. O'Brien, Jr., its director of research; J. H. Royston, L. G. Royston and other members of the staff, all of whom will be available for personal consultations.

RUST-OLEUM CORPORATION Booth 10

Large photographs showing applications of Rust-Oleum and literature on Rust-Preventives will be features of the Rust-Oleum Corporation, Evanston, Ill. exhibit.

Albert A. Ahlf, factory representative, will be at the booth.

SERVICE ENGINEERS, INC. Booth 56

A complete line of all types of gas meter insulation, other insulation and particularly the "S.E.I. Nut" the fruit of several years' research and study will be displayed by Service Engineers, Inc., Fort Worth, Texas.

Of interest to visitors will be a stand-meter with attendant piping to demonstrate the mechanical strength and electrical efficiency of various types of insulators. The ease of installation of the S.E.I. Nut also will be shown. Samples of all types of meter insulation will be furnished for take-home purposes.

Jim Clay and Guy Crawford, both registered engineers, will be at the booth for consultation on insulation problems involving special designs and unusual conditions.

TINKER & RASOR—Booth 43

Tinker & Rasor, San Gabriel, Cal. will exhibit four models of holiday detectors now being offered for sale and rental. These instruments are designed to cover requirements of all pipe line inspection and electrical inspection of dielectric coated conductors.

All Tinker and Rasor detectors are said to represent an advance in coating inspection, particularly with the use of direct current high-voltage output. Two light weight instruments designed for small and intermediate pipe diameters and two models for transmission line construction will be shown.

Model D-3 for small pipe diameters, particularly suited for gas distribution work and a new Model DS-3, designed for small and intermediate pipe diameters, particularly for double and triple wrapped asphalt applications, will be shown. Models C-3 and C-3X for transmission line construction, which have been in use on the West Coast for more than a year, also will be shown.

Mr. John P. Rasor will represent the company at the booth.

TRETO-LITE COMPANY—Booth 47

Kontol inhibitors developed to combat subsurface corrosion in pumping or flowing oil wells, gas wells and gas condensate wells will be featured in the exhibit of the Tretolite Company, Los Angeles, Cal. The organic inhibitors, when injected into a well, mix with fluids and absorb at the metal surface, forming a film which prevents corrosion, the company states.

The 1950 exhibit will show Kontol in stick form, although in the majority of field applications, especially in oil wells, the material is applied as a liquid. The sticks were developed for use where liquid injection is difficult or impractical. Kontol 201 is a high melting point stick for use in distillate wells and Kontol 231, a "heavy" stick with a density of about 2.0, is designed to be dropped down the tubing of wells containing fluid.

The exhibit also will show a scale model pumping oil well, with lighted panels showing where and how severe corrosion damage occurs.

Tretolite men who have been instrumental in development and application of the inhibitor will be present at the booth.

MEMBERSHIP CARDS AVAILABLE

Association members in good standing will be issued on request a membership card in the National Association of Corrosion Engineers. Address requests to A. B. Campbell, Executive Secretary, 919 Milam Building, Houston 2, Texas.

A list of addresses of new members and changes of addresses of old members is to be a monthly feature of CORROSION magazine.



Twenty-one years' experience providing a broad corrosion prevention service to the petroleum industry has brought NATASCO outstanding recognition in this field. This service is low cost insurance against corrosion damage. Our years of experience, plus carefully controlled manufacture of coatings, close supervision of surface preparation of tankage and application of the proper NATASCO products enable us to provide a guarantee on each completed job.

If you are connected with the pipe line or refining industries, you should know about NATASCO Service. Wire, write, or telephone for complete information.



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Corrosion Abstracts

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GENERAL

• Fundamentals

Measurements on the Oxidation-Resistance of High-Melting-Point Alloys. O. Kubaschewski and A. Schneider. *J. of the Inst. of Metals*, 75, 403-416 (1949) Feb.

Resistance to atmospheric oxidation of binary and ternary alloys was investigated at 1250° C by means of the apparatus described. X-ray and microscopic examinations and Brinell hardness measurements were also carried out, at room temperature, on alloys of chromium with tungsten and molybdenum. Data are graphed and discussed. 12 ref.—BLR.

Electrochemical Studies of Protective Coatings on Metals. I. F. Wormwell and D. M. Brasher. *J. Iron and Steel Inst.*, 162, No. 2, 129-35 (1949).

A description of an experimental technique for measuring changes with time of the electrode potential of painted steel immersed in artificial sea water. It has been shown that, by continuing the observations over longer periods than have been used by earlier workers, the electrical measurements can be closely correlated with the rate of breakdown of the paint as estimated visually and by determinations of weight loss of the underlying metal. The technique has been used to investigate the effect of paint thickness, the type of surface finish, the pretreatment before painting and the type of paint.—ZDA.

Investigation of the Variable Composition of Thick Layers of Rust. E. Palmær. Paper before Congress of Corrosion, Oct., 1947. *Metaux et Corrosion*, 24, No. 281, 23-28 (1949) Jan.

Chemical composition of different types of rust has been determined by analysis and has shown that in thick layers the closer one approaches to the metal the higher is the ratio of ferrous to ferric compounds, and that ferrous oxides are present in the form of hydrates. It appears that sulfur, phosphorus, and silicon are probably present in the rust in the form of sulphate, phosphate and silicic acid, and that the contents of carbon, silica, phosphorus and sulfur in the rust are often appreciably higher than they are in the metal.—INCO.

The Corrosion of Copper in Commercial Salt Solutions. W. Katz. (In German) *Metalloberfläche*, Ausgabe A, 3, No. 5, 101-105 (1949) May.

Investigation of kinetics of corrosion of copper in a solution containing 101 g/l. potassium chloride, 72 g/l. magnesium sulfate, 70 g/l. magnesium chloride and 138 g/l. sodium chloride; effect of temperature and alkaline buffers.—BNF.

Kinetics of Electrode Processes on the Iron Electrode. B. Kabanov, R. Burstein, and A. Frumkin. "Electrode Processes," Discussions of the Faraday Society, 1947, No. 1, 259-269; discussion, 298-302.

The following were studied on the basis of the literature and new data: influence of an oxide film on the anodic passivation of iron in alkaline solutions; mechanism of the dissolution and passivation of iron in alkaline solution; the electro-chemical process at potentials of about 0.95 v.; and anodic oxidation of iron in the presence of chlorine ions. A mechanism is proposed to explain the relationship between the formation of $\text{Fe}(\text{OH})_3$ and the passivation of iron upon anodic oxidation. The mechanism of the anodic dissolution of iron in the presence of both chlorine and hydroxyl ions is also discussed. 28 ref.—BLR.

TESTING

• General

Supersonic Inspection. *Weld. Eng.*, 33, 33 (1948) June; *Metals Rev.*, 21, No. 7, 26 (1948).

A description is given of this newly developed testing technique employing high frequency supersonic waves entering the welded part at an angle. It is a modification of the technique of the Sperry Supersonic Reflectoscope and is known as angle-beam transmission. It can be applied to the inspection of welds in plate, thin sheets, or sections where shape or contour is more or less uni-

form, and also to the inspection of internal defects. It is applicable to both ferrous and light metals.—MA.

Investigation of the Corrosion of Wire Specimens with Simultaneous Application of Steady Tensile Stress. N. D. Tomashov and V. A. Titov. (In Russian) *Zavod Lab.*, 15, No. 1, 48-53 (1949) Jan.

The apparatus used (illustrated) is constructed so that an electric clock is stopped when the specimen breaks. Results are given for the corrosion of iron wires in various solutions.—BNF.

• On Location Tests

Accelerated Weathering Tests. British Railways (L.M.R.) Paint Laboratory. *Oil Col. Trades J.*, 115, No. 2630, 579-86 (1948); also in *Railway Gas.*, 90, No. 8, 207-8, 217 (1949); *Rail. Eng. Abs.*, 4, No. 3, 82 (1949); *Paint Tech.*, 14, No. 159, 106-111 (1949).

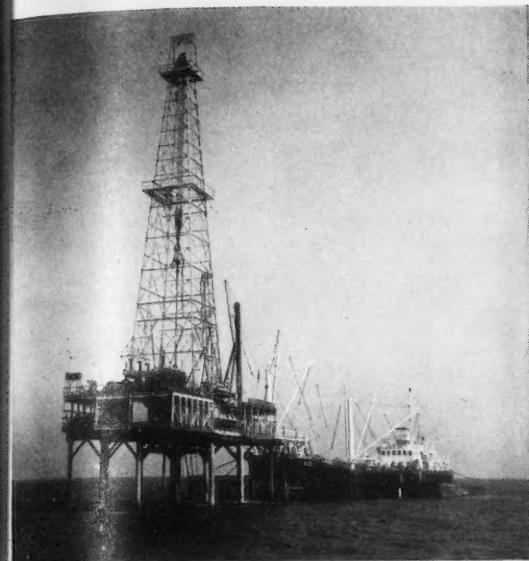
A description of the accelerated weathering tests carried out in the Derby lab. is given. Three test cycles are described: a) rural conditions, b) industrial conditions and c) extremely corrosive conditions. Tests b) and c) involve the use of SO_2 . Details of apparatus and methods of carrying out the tests are given. Tests on painted wood in the apparatus were unsatisfactory due to warping, consequent on rapid changes in moisture content, which induced paint failures not directly due to the nature of the paint.—RPI.

Influence de l'Humidité Relative et de l'État de surface sur la Corrosion de l'Acier à Faible Teneur en Carbone et du Zinc (The Effect of the Relative Humidity and the Surface State on the Corrosion of Low Carbon Steel and Zinc). F. Ogburn, E. R. Weaver and W. Blum. *Metaux et Corrosion (France)*, 24, No. 283, 77-84 (1949) Mar.

The greater part of this paper is concerned with the corrosion of steel, but a set of experiments with zinc also is reported. The rate of corrosion was measured for zinc test pieces exposed for periods of about 5 weeks to atmospheres of different relative humidities. The specimens were in four conditions, viz., cleaned with pumice, Cronak treated, cleaned and treated with sea water, and Cronak treated and treated with sea water. Up to 39 percent humidity, there was no appreciable corrosion of any specimen. At greater humidities the sea water-treated zinc corroded at a rate increasing rapidly with the humidity; Cronak treatment kept the corrosion rate low, though it still rose slightly as the humidity was increased.—ZDA.

• Laboratory Methods

Behavior of "Carbon Oxide" Resistant Materials in Contact with Water Gas Under Extreme Conditions. K. H.

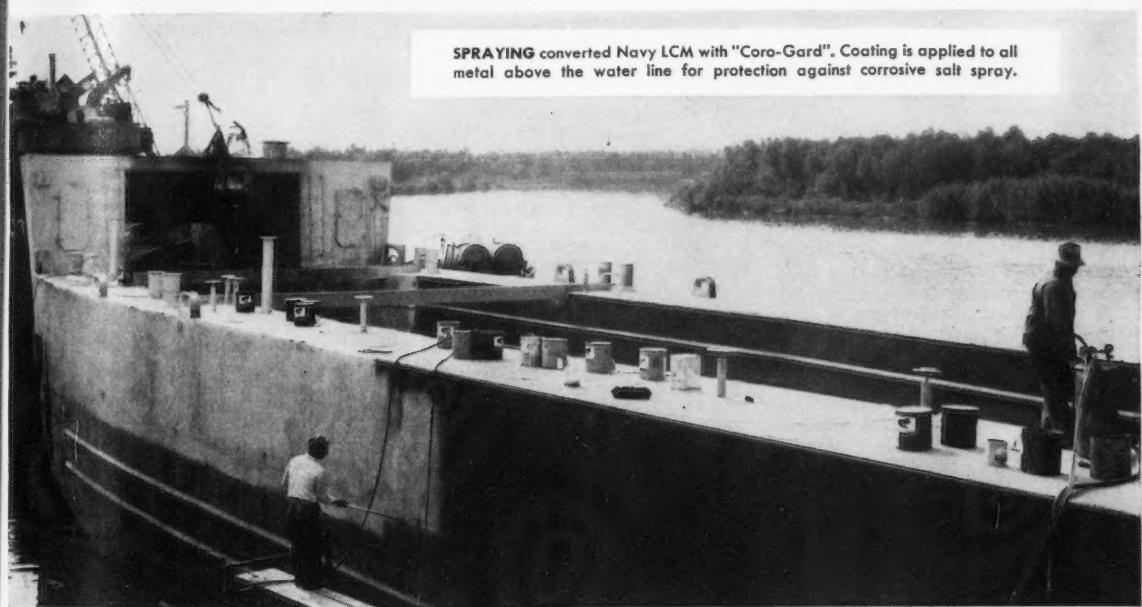


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Drill rigs and boats coated with "Coro-Gard" for longer life in corrosive salt waters

Now "Coro-Gard" protects drill rigs seven miles at sea—and their supply boats! Salt spray, immersion, high humidity, crude oil, rain squalls, and scorching sun have no effect on this tough anti-corrosive coating. Actual operating tests by a Gulf Coast oil company prove that "Coro-Gard" cuts expensive maintenance costs, requires less re-coating, gives long protection.

Whatever your corrosion problem, there's a "Coro-Gard" Coating System to save you time and money. Our engineers have prepared coating systems to satisfy every need. Write today for complete information.



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We'll be at the N.A.C.E. convention in St. Louis, Mo., from April 4th through April 7th. Stop at booth #76 in the Hotel Jefferson. We'll be glad to give you the latest information on "Coro-Gard" Coating Systems. You'll see for yourself how "Coro-Gard" saves!



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Abstract Section Style Outlined

For ease in locating reference data, *Corrosion* uses a uniform style in its Abstract Section.

The abstracts first are broken down into major classifications of the more common types of corrosion literature. In each review the title of the article is presented in bold face type, followed by the author's name. The publication from which the article was abstracted is printed in italics and is abbreviated in most instances. Following this, in sequence, are the volume (bold face), number in the volume, pages, year and month of publication. In some instances a second reference will be listed in the same manner. This indicates that the article also was published or abstracted in another publication. A brief summary of the article follows the above information and it is concluded with an abbreviation indicating the source of the abstract and contributor. The meanings of these abbreviations usually are listed on the first page of the Abstract Section.

When seeking more detailed data about an abstract, best source of information is the publication in which the article appeared originally. (Listed in italics in the heading.) The contributor of the abstract also may be able to supply additional information. Addresses of most of these publications may be found in the reference section of most public libraries.

Ziesecke. (In German.) *Chemie-Ingenieur-Technik*, 21, 15-18 (1949) Jan.

Twenty chromium steels and 6 non-ferrous metals were studied at 1000 atm. and temperatures of 300-450° C. Results are tabulated and evaluated from the standpoint of industrial application. A diagram shows the experimental furnace design.—BLR.

Experiments of Effect of Rolling Procedure and Annealing Temperatures on the Stress-Corrosion Resistance of Aluminum-Zinc-Magnesium Alloys. *Metalloberfläche*, 2, No. 7, 137-140 (1948) July; *Light Metals Research*, 9, 24; *Metallurgia*, 39, No. 233, 285 (1949) Mar.

Aluminum-zinc-magnesium alloy specimens differing in number of cold re-

ductions and in magnitude of final reduction in cold rolling were heat treated, aged at room temperature and tested for resistance to stress-corrosion by loop test with alternate immersion in 3% sodium chloride solution. In absence of vanadium there was no definite effect of cold rolling procedure on stress corrosion resistance. Specimens of extruded strips were rolled at 400°, 450° and 500° C., respectively, same temperatures being used, respectively, for intermediate cold rolling and for solution heat treatment of specimens. Results show that the higher the temperature to which it is heated, the more susceptible alloy is to a stress corrosion. Vanadium additions raise temperature to which alloy has to be heated before developing sensitivity to stress corrosion.—INCO.

Method for the Determination of the Corrosive Action of Insulating Varnishes on Copper. G. Winter, M. A. Jermyn and J. B. Houlihan. Australian Munitions Supply Laboratories, 1945, Rept. 162, *Prev. Det. Abs.*, 5, Met. 48 (1948)

A direct method for estimating the corrosive power of varnishes on copper panels is to assay the copper content of a) the varnish removed from the metal surface, b) the corrosion products on the metal surface. Suitable experimental procedures are outlined.—RPI.

Radioactive Tracers Used in Corrosion Studies. C. G. Bacon, Gen. Elec. Co. *Gen. Elec. Rev.*, 52, No. 5, 7-9 (1949) May.

Isotopes of common elements which participate in corrosion reactions, when made radioactive, can be followed through a series of chemical changes and combinations by use of photographic plate and a Geiger counter. Discussion includes radioactive material for laboratory tests, theory of process and analysis of data. Photograph in normal light and autoradiograph of same sample of iron plate after being corroded for 55 minutes are given.

Engineering Data Sheet—Thickness Testing of Electropolated Coatings. *Metal Fin.*, 46, No. 11, 87 (1948) Nov.

Tabulated data on microscopic, Mesle's

Chord, magnetic, chemical and electrochemical methods of testing electroplated coatings according to principle, advantages, disadvantages and remarks.—INCO.

Radioactive Tracers in Metallurgical Research. M. G. Fontana. *Ohio State Univ. Eng. Expt. News*, 20, No. 5, 39-41 (1948) Dec.

Describes application to study of diffusion processes, corrosion, steel-making, heat-treatment and hardening.—BNF.

Accelerated Weathering Tests. Anon. *Oil and Colour Trades J.*, 115, No. 2630, 579-86 (1949) Mar. 11.

A full description of the technique evolved by the Paint Laboratory of the Scientific Research Dept. of British Railways (L. M. Region) for the assessment of paint durability. The accelerated tests for polluted, humid and exposed conditions are described. A detailed account of equipment and experimental control is given, and the correlation of the artificial conditions to atmospheric weathering is discussed. The equipment used is warmly recommended as giving satisfactory and reproducible results.—ZDA.

Pilot Plant Corrosion Tests. I and II. M. G. Fontana. *Ind. Eng. Chem.*, 41, 101A-102A (1949) Mar. *Ibid.*, No. 4, 103A-104A (1949) Apr.

I. Pilot plant testing is ideal for obtaining corrosion data on structural materials under actual operating conditions which are often difficult to simulate in the laboratory. Some recommended procedures for preparing and locating and corrosion test pieces for pilot plant tests are detailed with photographs. Unless information on galvanic corrosion is wanted, the test pieces should be completely separated from other metals. The pieces may be arranged on a suitable metal rod covered with glass tubing, using sections of larger diameter glass tubing as spacers II. Discussion of temperature and time factors in pilot plant corrosion testing.—INCO.

Metallurgical Tracers and Naval Research. J. J. Harwood. *J. Amer. Soc. Naval Eng.*, 60, No. 1, 49-63 (1948) Feb.

Application of radioactive tracers to various problems, e.g., study of diffusion processes (including diffusion in stressed metals and through oxide films), molecular constitution of slags, and kinetics of reactions in the solid state.—BNF.

• Instrumentation

The Probolog, for Inspecting Non-magnetic Tubing. G. A. Nelson, Shell Development Co. *Metal Prog.*, 55, No. 1, 81-85 (1949) July.

A probe that sets up and measures eddy currents in walls can indicate irregularities in thickness of brass tubing due principally to corrosion or dezincification, and can thus spot defectives or tubes about to fail. Hitherto about all that could be seen in a tube bundle was a few inches of insides at either end. Instrument can also be used to explore condition of tubes prior to re-use, and to separate mixed lots by composition. Diagrams of corrosion encountered in condenser tubes after 18 months in steam condensers are included.—INCO.

GRIP-TITE STEARNS Pipe Line Anchor Assembly

Top view showing area of bearing surface on coating.

Galv. Rod→



**PROTECTS
PIPE
COATING!**

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at Corrosion Conference.

Originated and designed especially for protection to pipe coating, Grip-Tite Anchors with Stearns Pipe Saddle make positive permanent hold-downs for all kinds of pipe line construction through marshy, swampy or flooded lands. They eliminate the need of cast iron or concrete weights, save time, money and handling expense. They're field proved beyond any doubt!

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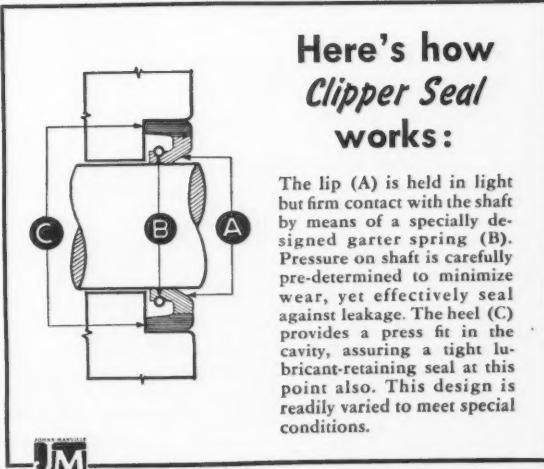
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PACKINGS & GASKETS

Characteristics and Field Use of Electrical Instruments for Corrosion Investigations and Cathodic Protection. M. C. Miller, Ebasco Services, Inc., New York, N. Y. Cathodic Protection, a Symposium, FCS and NACE. National Association of Corrosion Engineers, Houston, Texas (1948).

In connection with corrosion investigations or cathodic protection of buried structures many different direct current measuring instruments are available for the necessary field measurement of potential, current and IR drop (voltage drop due to dc flow along a metallic structure, such as a pipe line or cable sheath). Factors which influence the choice of instrument include damping, period, degree of ruggedness, portability, and sensitivity.

Potential measurements may include

the potential of rectifiers, batteries, galvanic anodes, and the surface of the earth, or the potential of the buried structure with reference to the earth along the structure or to other metallic structures. Four types of millivolt/voltmeters are used: 1) low resistance instruments, 2) high resistance instruments, 3) vacuum-tube voltmeters, and 4) potentiometer/voltmeters. The measurements chosen for a specific purpose should not pass sufficient current to change the potential being measured nor polarize the reference electrode and change its half-cell potential. The internal resistance should be very high compared with the external resistance of leads and resistance to earth of reference electrodes.

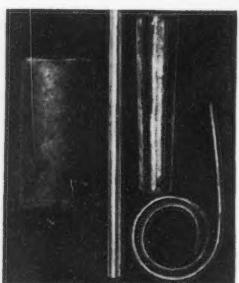
The principal advantage of the potentiometer is that it acts as a voltmeter

with practically infinite resistance. It is worthless, however, in electrolysis testing where potentials fluctuate rapidly. Vacuum-tube voltmeters are useful because the very high input resistance tends to reduce errors in measurements caused by high resistance of the external circuit.

Practically all dc instruments used in field measurements of current are basically microammeters or milliammeters with shunts where necessary. The moving element most used is a low resistance milliammeter with a 50-mv drop shunt. Instruments with a 20-mv drop shunt, have many advantages and allow direct reading in cases where otherwise a zero resistance type of instrument would be indicated. The currents measured are battery or rectifier currents, electrolysis drainage, galvanic currents between structures, and galvanic anode currents. These may vary from hundreds of amperes to a few microamperes. Where the resistance of the external circuit is very low or difficult to determine, a zero-resistance type of ammeter is desirable.

A Multi-Combination Meter has been developed in which all the instruments necessary are assembled in one compact unit. It is versatile, small in size and weight, and eliminates the connecting of separate instruments. Even though high sensitivity instruments are used, the period and damping are almost ideal for field testing. The accuracy of all potential and current ranges and of scale markings is greater than 0.5%. The various measurements which can be made on each position of the selector switch are described.—PDA.

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Wood To Be Used as Panels in Weathering Tests of Paints and Varnishes. D358-48T. ASTM Book of Standards Suppl. Pt. 11, 230-2 (1948)—RPI.

Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys. *ASTM Bull.*, 1949, No. 157, 11, Mar.

Committee B-3 reviewed a number of its current test programs with regard to the status of various testing methods in its charge. The Subcommittee on Spray Test is recommending minor changes in the Method of Salt Spray (Fog) Testing (B117) to improve the control of testing conditions and to make the method applicable for painted panels. Studies of the acetic acid-salt spray test for plated diecastings and on the effect of various concentrations of salt solutions have been made. The subcommittee on weather in the spring of 1948 prepared and exposed "pilot" test samples at a number of test locations to study the relative corrosiveness of various atmospheres, and a paper by Mr. O. B. Ellis on this study, entitled "Factors in Measuring the Corrosiveness of the Atmosphere," will be appended to the committee's annual report. The subcommittee on Galvanic and Electrolytic Corrosion reported that the disk samples with the aluminum and magnesium couples will be exposed at several locations early this summer.—ALL.

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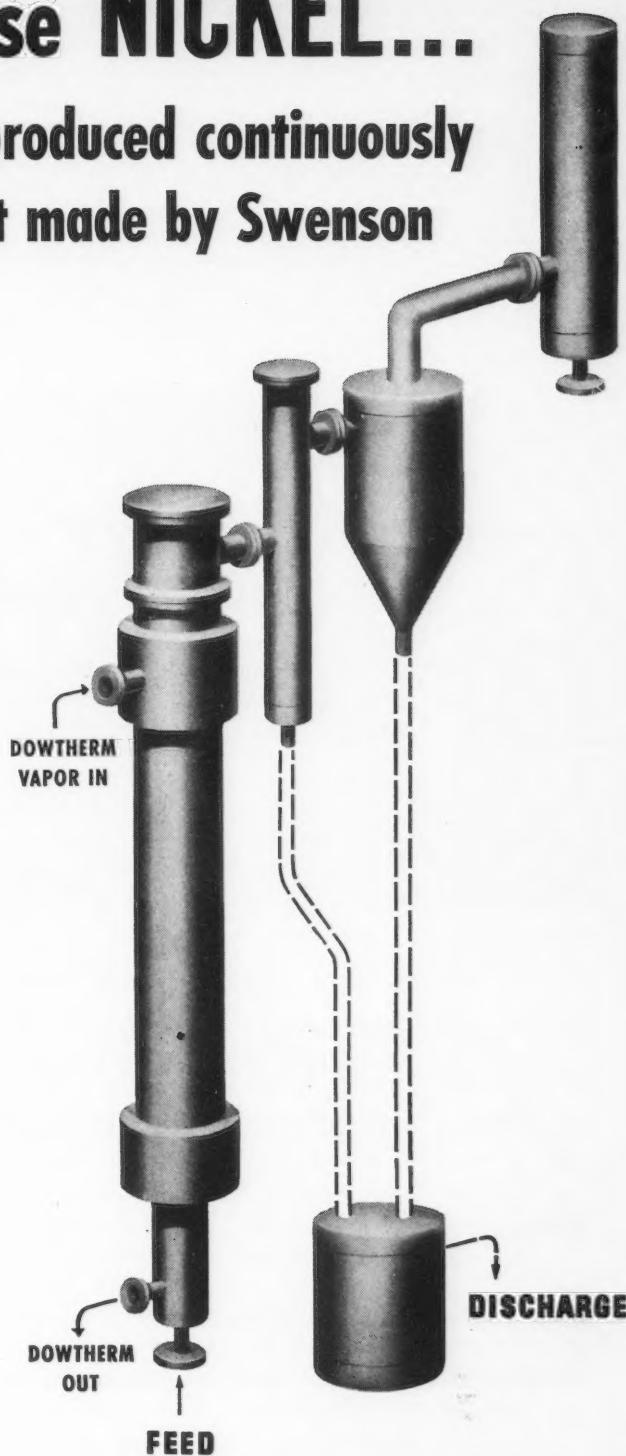
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First Report of the Methods of Testing (Corrosion) Sub-Committee. British Iron and Steel Research Assn., London. Metallurgy (General) Division, Paper MG/BF 29/47. *J. Iron Steel Inst.* (London), **158**, 463-493 (1948) Apr.

Experimental work carried out by the Sub-Committee on Methods of Testing (Corrosion) is the basis for the Provisional British Standard No. 1391: 1947, 'Performance Test for Protective Schemes Embracing Stoving Paints Used in the Protection of Light-Gauge Steel and Wrought Iron against Corrosion.' A sea-water spray test devised by the Armament Research Department (ARD) was selected from different test methods as most suitable and was standardized to insure reproducibility of the results. Reasonable standards of performance for protective schemes embracing single coats of stoving paints applied over phosphated or nonphosphated steel were determined by testing typical industrial finishes. The results of these tests and a statistical analysis especially relating to quality control are reported.—PDA.

Standardization of the pH Scale. *Tech. News Bull. Nat. Bur. Stand.*, **31**, No. 12, 138-139 (1947).

The pH unit, used to express numerically the degree of acidity or alkalinity of aqueous solutions, may be defined in a number of ways, each resulting in a slightly different value of the pH of a given solution. In view of the need in science and industry for accurate determinations of acidity, the NBS recommends the universal adoption of a standard pH scale analogous with International Temperature Scale, and the pH of NBS standards is now derived from measurement of the emf of cells without liquid junction, in which they are used as electrolytes. Hydrogen and silver-silver chloride electrodes, which are readily reproducible, are used.—MA.

Ordnance Inspection Handbook on Metals. (Ord.-M608-1) U. S. Ordnance Dept. (1947) July.

This handbook is a profusely illustrated summary of numerous methods for testing and inspecting metallic materials. The most widely used tests of the following types are described in detail: visual, mechanical or physical, chemical, magnetic, electrical, radiographic, metallic coating tests, sonic and supersonic, penetrating oil methods, and special tests.

Considerable attention is given to general inspection instructions and to process inspection, the latter including information on pyrometry. A comprehensive glossary of technical, lay, and trade terms is included.—PDA.

Nitriding. H. Wiegand. *Revue de Metallurgie*, **45**, 105-117 (1948), Abstract in *Engineers' Digest*, **9**, 423-424 (1948) Dec.

In the nitriding process the diffusion of nitrogen produces an increase in volume of the outer zone which sets up compression stresses on the outside and tensile stresses inside. The compressive stresses in the nitrided case lead to an increase in fatigue resistance, and this increase rises with the depth of the nitrided layer to a certain maximum for each category of steel, so that there is an optimum ratio (found by trial) between the thickness of the nitrided layer and the cross-section on the work-piece in question. It may not always be possible to attain this optimum, as the nitriding time would be too long. There is no relation between surface hardness after nitriding and fatigue resistance, as the latter depends on the ratio of nitride thickness to cross-section and tensile strength of the core steel. For a part subjected only to alternating stresses, a high surface hardness is not essential. Surface roughness is of no consequence with nitrided steel, although the surface finish is so important with non-nitrided steels. For crankshafts, the greatest increase in endurance is obtained by nitriding all over. If only part-nitriding is done, the radius as well as the pins should be nitrided. Tests have shown that radial engine crankshafts nitrided all over showed a fatigue resistance 15 percent greater than similar crankshafts

which were nitrided on the pins only. Machining of crankshafts to be nitrided all over is less costly than in the case of non-nitrided crankshafts, as the latter must have a very high surface finish to avoid the setting up of fatigue cracks. Similar remarks apply to connecting rods, for which nitrided steel helps to overcome trouble due to fretting corrosion between the bronze bearing and the big end of the rod. A nitrided steel connecting rod under alternating stress tests stood up to 1,560,000 stress reversals as against 39,000 with the non-nitrided steel.—TIME.

CORROSION TYPES & INFLUENCING FACTORS

● Factors Chemical

Influence of Low Temperatures on the Mechanical Properties of 18:8 Chromium-Nickel Steel. U. S. National Bureau of Standards, Research Paper RP1882. D. J. McAdam, Jr., G. W. Geil and Frances Jane Cromwell. *J. Res. Natl. Bur. Stand.*, **40**, 375-392 (1948) May.

By means of tension tests of notched and unnotched specimens the mechanical properties of seven 18:8 chromium-nickel steels were investigated at room temperatures, -78° C, and -188° C. One of the steels was ferritic, the others were of the metastable austenitic type. Plastic deformation of the metastable alloys causes a phase change and thus hardens the alloy, the rapidity of change increasing with a decrease in temperature. Since this hardening is so rapid at low temperature that the load-extension curve sometimes has two maxima, six important strength indices are sometimes required to evaluate the mechanical properties. These indices are yield stress, first ultimate stress, stress at a minimum in the load-extension curve, stress at a reversal of the load-extension curve, second ultimate stress, and true fracture stress.

Results are presented graphically for the various alloys at the three temperatures showing: 1) variation of the nominal stress with tensile extension, 2) variation of true stress with strain and 3) variation of strength between room temperature and -188° C. Curves are also presented for variation in strengths of the 18:8 steel and of some other metals between room temperature and -252.8° C.

Qualitative tests of magnetic changes with plastic deformation confirm the theory that the rapid raise of the flow-stress with plastic deformation at low temperatures is caused by a rapid transformation of austenite to ferrite.

A study of the influence of notches on mechanical properties suggests that the ultimate stress of these specimens is appreciably increased by the phase change during plastic deformation. This change evidently contributes to the toughness of both notched and unnotched samples.—PDA.

Fretting Corrosion. *The Engineer (England)*, **177**, No. 4853, 104 (1946) Jan. 28.

Among the more recent theories put forth on the subject of fretting corrosion was that contained in a paper by H. Schottky and H. Hiltenkamp (translated by R. G. Sartorius, *Steel*, **123**, 57, July 5, 1949). There have been on record at the Krupp Laboratory, Essen, for many years, observations to the effect that at

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PRIMARY SOURCES OF ABSTRACTS PUBLISHED IN CORROSION

AER—Aeronautical Engineering Review, Institute of Aeronautical Sciences, Inc. 2 East 64th St., New York 21, N. Y.

ALL—The Abstract Bulletin, Aluminum Laboratories, Ltd. P. O. Box 84, Kingston, Ontario, Canada.

AWWA—Journal, American Water Works Association, Amer. Water Works Assoc., 500 5th Ave., New York 18, N. Y.

BLR—Battelle Library Review, Battelle Memorial Institute Library, 505 King Ave., Columbus, Ohio.

BNF—Bulletin, British Non-Ferrous Metals Research Association, 81-91 Euston St., London NW 1, England.

CALCO—Calco Chemical Division, American Cyanamid Corp., Bound Brook, New Jersey.

CE—Chemical Engineering, McGraw-Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

CEC—Consolidated Edison Co. of New York, Inc. 4 Irving Place, New York 3, New York.

EW—Electrical World, McGraw-Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

GPC—General Petroleum Corp. of California, 2525 East 37th St., Los Angeles 11, Calif.

INCO—The International Nickel Co., Inc. 67 Wall Street, New York 5, New York.

IP—Institute of Petroleum, 26 Portland Place, London W#1, England.

MA—Metallurgical Abstracts, Institute of Metals, London, England, 4 Grosvenor Gardens, London SW 1, England.

ME—Marine Engineering, The Institute of Marine Engineers, 85/88 The Minories, London E. C. 3, England.

MR—Metals Review, American Society of Metals, 7301 Euclid Ave., Cleveland 3, Ohio.

NALCO—National Aluminate Corp. 6216 West 66th Place, Chicago 38, Illinois.

NBS—National Bureau of Standards, Supt. of Documents, U. S. Govt. Printing Office, Washington 25, D. C.

PDA—Prevention Deterioration Abstracts, National Research Council, 2101 Constitution Ave., Washington 25, D. C.

RA—Refrigeration Abstracts, American Society of Refrigeration Engineers, 40 West 40th St., New York 18, N. Y.

RM—Revue de Metallurgie, Paris, France, 5 Cite Pigalle, Paris (9e), France.

RPI—Review of Current Literature Relating to the Paint, Colour, Varnish and Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London. Waldegrave Rd., Teddington, Middlesex.

TDD—Technical Data Digest, Air Material Command—Technical Service Section, Central Air Documents Office, Wright-Patterson Air Force Base, Dayton, Ohio.

TIME—Transactions of Institute of Marine Engineers, 85 The Minories, London EC 3, England.

UOP—Universal Oil Products, 310 South Michigan Ave., Chicago, Illinois.

ZDA—Zinc Development Association, Lincoln House, Turl Street, Oxford, England.

No Code—Current Technical Literature, Bell Telephone Laboratories, 463 West Street, New York 14, New York.

mospheric nitrogen, rather than oxygen, has a strong influence on surface destruction by galling. Chemical analysis of scrapings from a leaf of a clutch spring showing a friction spot showed an increase in nitrogen and further, that the less oxide is present the higher is the nitrogen content. Similar analyses on the tooth of a badly worn gear wheel gave, to a depth of 0.04 mm, an average nitrogen content of 0.013 percent in a severely roughened part, 0.008 percent in a little worn part, and 0.004 percent in the interior. These results proved that under severe friction that nitrogen as well as oxygen is absorbed from the atmosphere. In further support the authors quoted observations showing that absorption of nitrogen takes place during the machining or grinding of micro sections of soft iron. Some brittleness and crumbling of the surface layers could be explained by the formation of nitrides at the grain boundaries, but the examples presented did not appear to be typical of fretting corrosion.

Whatever may be the primary cause of fretting corrosion, experience has shown that it only occurs as a result of slipping or rubbing motion, which may involve only very slight relative movement. The severity of fretting corrosion is increased with more highly finished surfaces, hard metals being more affected than soft ones.

• Factors Metallurgical

Galvanic Corrosion in Oil and Gas Well Fluids. F. L. LaQue. *Corrosion*, 5, 86-91 (1949) Mar.

In a discussion of the factors which, under certain conditions, will retard galvanic corrosion to a tolerable limit, the author refers to the area effect. Where the corrosion reaction is under cathodic control, which is commonly the case, the extent of galvanic acceleration of the corrosion of the anodic material will be determined by the relationship between the area of the cathodic mate-

rial. Consequently where the exposed area of the cathodic material is relatively small the galvanic action may be negligible. Examples are provided by Monel fastenings in contact with a steel plate in aerated sea water which showed no evidence of accelerated corrosion of the steel where it had been in contact with the Monel bolt, nut and washer assemblies. Similarly, carbon and low alloy steel plates welded with 25 per cent chromium-20 percent nickel austenitic stainless steel welding rods showed no acceleration of corrosion alongside welds after exposure in sea water for over two years.—TIME.

Secondary Zinc-Base Alloys. D. P. Oakley. *Metal Ind.*, 72, No. 6, 113 (1948) Feb. 6.

The effect of intercrystalline corrosion caused by the impurities tin, lead and cadmium in secondary zinc-base alloys is discussed, with precautions against them in manufacture. Working details and temperatures for their use in pressure die-casting are given. By controlling percentages to max. figure of 0.005 tin, 0.005 cadmium and 0.007 lead, and adding magnesium, the alloy will withstand a warm humid atmosphere, without perceptible attack. Effect of high or low copper content is also discussed, and chemical compositions of BS 1004-A and B, and BS 1141 are given. Aluminum ranges between 3.9 and 4.3 and copper between 0.03 and 1.0.—INCO.

The Stress - Corrosion of Metals. (ASM) Sub-Committee on Stress-Corrosion, Metals Handbook, (Amer. Soc. Metals), 1948, 227-228.

A brief description of the nature of stress-corrosion and the mechanism of stress-corrosion cracking.—MA.

Intergranular Corrosion in Chromium-Manganese Steels. L. Wetternik. *Archiv. Metallkunde*, 2, No. 9, 315-316 (1948).

Critical study of laboratory test developed by L. Schaeben for determining susceptibility of high alloy chromium-manganese steels, 2 of which contain

small amounts of nickel, to intergranular corrosion.—INCO.

What Causes Localized Corrosion? R. B. Mears, Carnegie-Illinois Steel Co. Paper before Electrochem. Soc., Niagara Falls. *Steel*, 124, No. 11, 86-89, 128 (1949) Mar. 14.

Localized corrosion of metal surfaces is attributed to presence of impurities in corroding metal. Other causes are: metallurgical factors, including grain boundaries, orientation of grains, differential grain size, and differential heat treatment; surface roughness, including local scratches and abrasions; differential strain; differential pre-exposure to air or oxygen; differences in degree of aeration, heating illumination and agitation; difference in shape and contact with dissimilar metal; certain complex cells which may influence corrosion factor, and externally applied potentials. Each of the factors are discussed and throughout is mentioned the basic corrosion curve showing relationship between increasing corrosiveness and percent of exposed area of metal surface suffering attack. Among photomicrographs are specimens of stainless steel.—INCO.

Properties of Melted and Forged Titanium-Chromium Alloys. D. J. McPherson and M. G. Fontana. *Metal Prog.*, 55, 366-367 (1949) Mar.

Induction-furnace-melted alloys were largely unsatisfactory; most of the work was done with arc-melted alloys prepared at Battelle Memorial Institute. Describes mechanical properties, acid and salt-solution corrosion; scaling characteristics; and microstructure as forged and after annealing and quenching.—BLR.

CORROSIVE ENVIRONMENTS

• Soil

A Case of Corrosion Involving Cinders. C. H. Thompson. Paper before NACE, Apr. 5-8, 1948, St. Louis, Mo. *Corrosion*, 5, No. 5, 151-154 (1949) May.

A galvanic couple was set up between an iron gas main, through carbonaceous matter in cinders (which has been used to fill up excavated area at a culvert), and a sheathed cable, giving rise to severe corrosion of the latter. Substitution of sand for cinders and removal of cinders adhering to the gas main stopped the trouble.—BNF.

The Underground Corrosion of Lead, Zinc and Galvanized Materials. Anon. *Ind. Finishing* (U. K.), 444-5 (1949) Feb.

An account of a paper presented at the American Gas Association's 1948 Joint Production and Chemical Committee Conference. Useful data on the corrosion of rolled and cast zinc and galvanized steel and iron in different soils are recorded. The specimens were exposed for 10 years and it was discovered that though the zinc was attacked by the soils which attacked ferrous materials, the protective action of the zinc coatings was considerable. There is some indication that the zinc-iron alloy layers were very resistant to the corrosive action of the soils.—ZDA.

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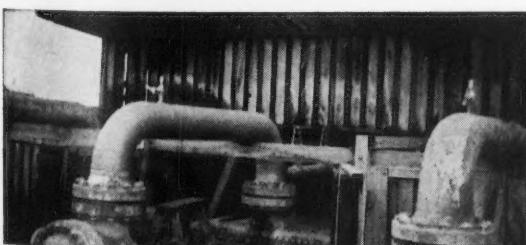


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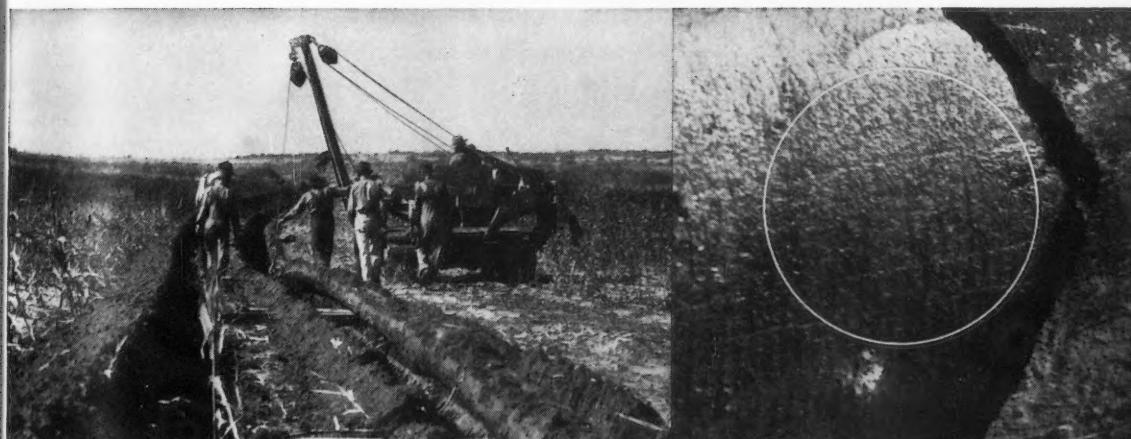
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● Water

Amine Volatility and Alkalinity in Relation to Corrosion Control in Steam Heating Systems. A. A. Berk and J. Nigon, U. S. Dept. of Interior, Tech. Paper 714, Washington, D. C. (1948).

Investigation conducted as cooperative project of Bureau of Mines, and Repairs and Utilities Branch of Office of Chief of Engrs. Corrosion tests run to compare usefulness of several amines for treatment of steam systems to prevent return-condensate corrosion. For comparison, studies included tests of corrosiveness of condensate from untreated steam of low and high carbon dioxide contents. No active corrosion occurred at any of the tests when amines used. No single factor appeared to be responsible for such minor corrosion as was observed in alk. solns. resulting from amine treatments. No unique inhibiting properties peculiar to any one amine found for those studied. Batch feed at 8-hr. intervals appeared to be effective as continuous treatment for providing alk. condensates and thus preventing corrosion. Corrosion produced by acidic condensate on coiled-wire test specimens tended to be increased by increased carbon dioxide content and also by increased flow. Effect of temp. and dissolved oxygen upon such corrosion apparently less important. Data do not warrant more definite conclusions on factors influencing corrosion. More enlightening data expected from addnl. tests now in progress. Of 3 amines used, cyclohexylamine very volatile in boiling water and quite alk., benzylamine moderately volatile and moderately alk., and morpholine least volatile and only mildly alk. High volatility tends to result in losses during de-aeration; low volatility tends to result in losses in blow-down. High alk. tends to prevent removal of carbon dioxide, thereby increasing percentage recirculation of this substance and its concn. in system. Higher concn. of amine required in system, greater amine makeup required, as, in general, losses due principally to wasted condensate. Concn. of morpholine tends to decrease during distr. of steam at low pressures (5 psi). Where such lines long and much steam lost through condensation in piping, use of morpholine not recommended. Amine which in very dilute soln. distilled without change in concn. at atmospheric boiling point would then be regarded as having min. required volatility. Calculations made comparing amine makeup required for each treatment when 500,000 lb. of steam was generated and feed-water makeup, contg. 200 ppm. free and combined carbon dioxide, was 6, 12 and 20%. Comparisons made at blowdown rates of 2 and 5%, based upon load. From standpoint of quants. used, cyclohexylamine appeared to be less desirable than either morpholine or benzylamine under chosen conditions. Morpholine somewhat superior to benzylamine when blowdown small compared to makeup, but reverse true when blowdown made relatively high. These conclusions apply to particular plant that was operated at 60-psi steam pressure and had de-aerating heater operated at 215°-220° F. At high steam pressures, comparison probably would be even less favorable to cyclohexylamine and more favorable to morpholine. At lower pressure, inexpensive

amine of volatility higher than that of morpholine would appear to be most suitable.—NALCO.

Cooling Water Treatment. V. J. Calise, Liquid Conditioning Corp. *Petr. Eng.*, 21, No. 1, A 3+ (1949) Jan.; *Ibid* No. 3, A 56+ (1949) Mar.

Cooling water problems include a) excessive scale, b) corrosion, c) organic growths, d) presence in the water of materials that prevent the formation of thin protective scales, e) presence of suspended matter in the water, and f) tube leakage.

This article, Part I of a series, discusses scale and corrosion.

The author discusses at length corrosion prevention through formation of a controlled calcium carbonate protective coating using the Langmuir Saturation Index and other empirical factors. The procedure is given for determining proper treatment for a given make-up water in order to obtain a thin protective calcium carbonate coating for maximum uniformity.

Part II of this article gives three actual examples of installations using the controlled scale method. Also discussed are other treatments, including phosphates, organic materials and chromates for scale and corrosion control.—NALCO.

Biological Reactions of Polluted Industrial Waters on Copper-Bearing Alloys. C. O. Evans. Engineers' Society of Western Pennsylvania, Eighth Annual Water Conference, Paper 4, Nov. 12, 1947, 14 pp.

In this paper the author presents the thesis that more condenser tube corrosion is due to bacterial action than is actually appreciated. Suggestions as to how various types of bacteria could take part in a corrosion reaction are given but no experimental proof is submitted nor, apparently, is research contemplated.—BNF.

Basic Principles of Corrosion Control by the Use of Lime. Edward S. Hopkins (Baltimore Dept. of Public Works). *Paper Trade J.*, 127, No. 1, 61-63 (1948) July.

Neutralization of free carbon dioxide in low alkaline waters by lime, and the subsequent precipitation of a calcium carbonate-ferric oxide coating on pipe surfaces considerably reduces corrosion. Water thus treated is stable when maintained at the calcium carbonate saturation point.

Even though complete elimination of corrosion may not be accomplished by treatment of water, the value of the reduction where the water is fairly corrosive greatly exceeds the cost of treatment. It is believed that corrosive treatment with lime will produce a water of considerable economic value to many industries.—PDA.

Effect of Chlorination of Drinking Water on Brass Fittings. H. Ingleson, A. M. Sage and R. Wilkinson. *J. Inst. Water Eng.*, 3, No. 1, 81-91 (1949) Jan.

An account of an investigation carried out jointly by the Water Pollution Research Laboratory (Department of Scientific and Industrial Research) and the BNFMRA. Metallographic examination was made of cast (single phase brass) and hot-pressed (two-phase brass) ball valve seatings after exposure under service conditions to various types of waters, chlorinated and unchlorinated. This paper is substantially the same as BNF

Technical Memorandum 60, "Corrosion of Brass Ball Valves in Chlorinated Waters," by A. M. Sage, which was made available to members in August 1948.—BNF.

Calculated and Experimental pH Values and Contents of Corresponding Carbon Dioxide in Natural Waters and the Reason for Differences. J. Kegel (In German.) *Archiv Metallkunde*, 2, No. 1, 18-22 (1948) Jan.—BNF.

The Resistance of Metallic Silver to Marine Fouling. Alfred C. Redfield and Charles M. Weiss. (Woods Hole Oceanographic Institution, Contribution No. 411). *Biol. Bull.*, 94, No. 1, 25-28 (1948) Feb.

A specimen of coin silver, which contains about 10% copper, remained entirely free of fouling throughout an exposure of 1 year in the sea at Miami Beach, Fla. Two panels of pure silver began to foul within 1-2 mo., and both were completely covered at the end of 4 months of exposure. One of the pure silver specimens has been presoaked in sea water 2 months prior to test; the corrosive coating thus formed resisted fouling during the early months of exposure better than a clean surface of bright silver. Coin silver is believed to be more resistant than pure silver to fouling because of its higher rate of solution when exposed in the sea.

There was no indication that the surface of silver from which solution was prevented by coupling with zinc or iron had any antifouling effect; pure silver specimens thus treated fouled heavily during the first month of the 12-month test period. Silver coupled to nickel showed slight resistance to fouling only during the first 2 months; contact with copper had scarcely any effect. The results were proportional to the differences in potential of the coupled metals—PDA.

Effect of Non-Condensable Gases on Corrosion of Nickel in Steam Condensate. W. A. Wesley and H. R. Copson, International Nickel Co. Paper before Electrochem. Soc., Philadelphia, May 4-1949. Bayonne Tech. Paper No. 164, Oct. 15, 1948. *J. Electrochem. Soc.*, 95, No. 3, 226-241 (1949) May.

Discussion includes field observations, apparatus, standard procedure, effects of temperature, composition of non-condensable gases, time, and pressure, passivity of nickel in steam condensate, corrosion rate of nickel in presence of iron, effect of purity of condensate, corrosion product, corrosion of iron in steam condensate, corrosion of Inconel, corrosion of other metals, and preventing condensate corrosion of nickel tubes. Corrosive conditions to which chemical evaporator tubes may be exposed on steam side were simulated in corrosion tests run in hot water saturated with mixtures of CO_2 and air under pressure. These showed that appreciable corrosion of nickel can occur in a critical range of composition of non-condensable gases, namely from about 55-90% CO_2 by volume. In presence of iron corrosion products, this range is broadened to include 40-90% CO_2 . Outside critical range, nickel owes its good resistance to development of a passive film. Corrosion of nickel is prevented by removing air or CO_2 from steam until their ratio is no longer critical. Inconel, tin, and stainless steel were resistant to attack under all experimental conditions. Zinc and some

60, "Corrosion in Chlorinated Ge, which was in August, copper alloys were also tested. Five variables include one on corrosion of various metals. Among graphs are those illustrating effects of temperature, composition of non-condensable gases at various temperatures, and time on corrosion rate of nickel in steam condensate.—INCO.

(1) **Corrosion Cracking of Welded Mains.** (2) **Corrosion of Gas Appliances.** Gas Research Board. Report of the Director for the Year 1947, Gas Research Board Publication GRB 37/21, (I) p. 26, (II) pp. 45-48 (1948) Nov.

(1) briefly reports work in progress; (2) gives results of experiments with instantaneous water heaters: corrosion on the gas side and deposition of scale on the water side.—BNF.

Salt Water Corrosion of Ships— Bethon, W. Beck. *Corrosion*, 4, 421-422 (1948) Aug.

In the discussion of this paper, Professor W. Beck points out that stray current troubles on ships can be expected in the case of a bipolar as well as in a unipolar installation of the electrical supply system. It is practically impossible to keep the insulation (e.g., of the enormous number of negative return cables) constantly in perfect condition. But local defects in the insulation may lead to the formation of dangerous potential differences on the body of the ship, and consequently, on any machinery, etc., in contact with it. For example, with a surface condenser or a pumping plant, the probability of electrolytic attack of the metal is very high. In this connection it must be taken into consideration that the consumption of electrical energy on shipboard is enormous.

On a well-known ocean steamer of medium size, the maximum consumption of electrical current approximates 20,000 amperes. If the electrical supply network is unipolar, the whole body of the ship represents a part of the return feeding system. Also, it can be expected that a number of the machine installations will be connected in parallel to the ship body. A transfer of current to an electrolyte solution may lead to anodic corrosion, and hence to considerable damage to the hull. In many cases it was observed that pin heads and rivet shanks were attacked by stray currents on ships with a unipolar electrical installation. In some cases electrolytic corrosion could be reduced by connecting the endangered conductor to the negative bus bar of the generator. In special cases cathodic protection gave very good results. When electrical welding is utilized in ship building, it is recommended to avoid negative ground connections but to connect the parts to be welded directly to the negative pole of the welding dynamo.—TIME.

Water Treatment Makes Big Strides—Further Development Promised. R. C. Bardwell, Superintendent Water Supply, C. & O. R. R., Richmond, Va. *Railway Eng. and Maintenance*, 45, No. 4, 388 (1949) April.

Recent developments in water treatment on the railroads include 1) practical elimination of internal boiler pitting and corrosion, 2) reduction of hardness of lime-soda ash treated water by use of sodium aluminate, 3) reduction of incrustation in pre-boiler system by use of complex polyphosphates, sometimes mixed with tannins, 4) great reduction of caustic embrittlement through use of

sodium nitrate or suitable organic materials, 5) reduction in blowdown volume through use of antifoams, 6) development of conductivity sets calibrated to read boiler water salts direct, 7) recirculation of sludge and refinements in sludge-blanket type softeners, and 8) standardization of water analysis methods and interpretation.

Future developments probably will concern sludge-blanket lime-soda plants, tannins and other organic materials, polyamide antifoams, and improved water conditioning for Diesel units.—NALCO.

PREVENTIVE MEASURES

• Packaging

Metals in Food Production. R. K. SANDERS. Some Aspects of Packaging in Metal Containers. *Chem. & Ind.*, No. 10, 151-155 (1949) Mar. 5.

Discusses containers especially for food packaging: fundamental requirements, leakage (including penetration of microorganisms), mechanical strength and rigidity, corrosion (of aluminum, steel and tin plate), methods of opening, etc. A short version of this paper has already appeared.—BNF.

Zinc Anode Protection in Dry Cells. *Chem. Eng. News*, 26, No. 37, 2711 (1948).

A note. Heterocyclic organic compounds such as quinoline, p-dipyridyl, and quinaldine, &c., are stated to be effective in reducing the corrosion of zinc in dry-cell electrolytes. Modifications of the paste wall to increase its inhibiting characteristics are also suggested.—MA.

• Inhibitors

Dissolution of Aluminum in Sodium Hydroxide Solutions—Effect of Gelatin and Potassium Permanganate. M. A. Streicher. *Ind. and Eng. Chem.*, 41, No. 4, 818-819 (1949) Apr.

The dissolution of commercially pure aluminum (99.2% aluminum) in 0.3 N sodium hydroxide solution at 23° C (73.4° F) has been modified by the addition of gelatin and potassium permanganate. The addition of 0.5% gelatin to this solution reduces the weight loss of aluminum by 50%. When potassium permanganate is added in quantities below 0.06% there is an increase in the weight loss. To decrease the weight loss in this solution 0.1% potassium permanganate is necessary. Electrode potential measurements were made in the various solutions studied. A mechanism is suggested for the action of these inhibitors. 10 references.—ALL.

Trail Refuses to Trail in Chemical Pioneering. S. D. Kirkpatrick. *Chem. Eng.*, 55, No. 4, 96-99 (1948) Apr.

Discussion of the chemical and metallurgical operations of the Consolidated Mining & Smelting Co. includes use of by-product O₂ in contact H₂SO₄ production, gasification of coal, zinc and lead smelting. Severe corrosion occurred in convertors and heaters and much research was done on this problem and on catalyst behavior at high tempera-

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tures and gas concentrations. Flow-sheet of cyclic sulfuric acid process used in a redesigned contact unit and other illustrations are included.—INCO.

Some Problems of Corrosion and Erosion in a Eucalyptus Sulphate Pulp Mill. S. C. Johnson. *Proc. Australian Pulp and Paper Industry Tech. Assn.*, 1, 99-105 (1948).

Cracking and corrosion in chipper knives of carbon steel are described. Knives made from steel containing 2% carbon, 12% chromium, operate about 8 times longer than the carbon steel ones. Corrosion in digesters is considered.—INCO.

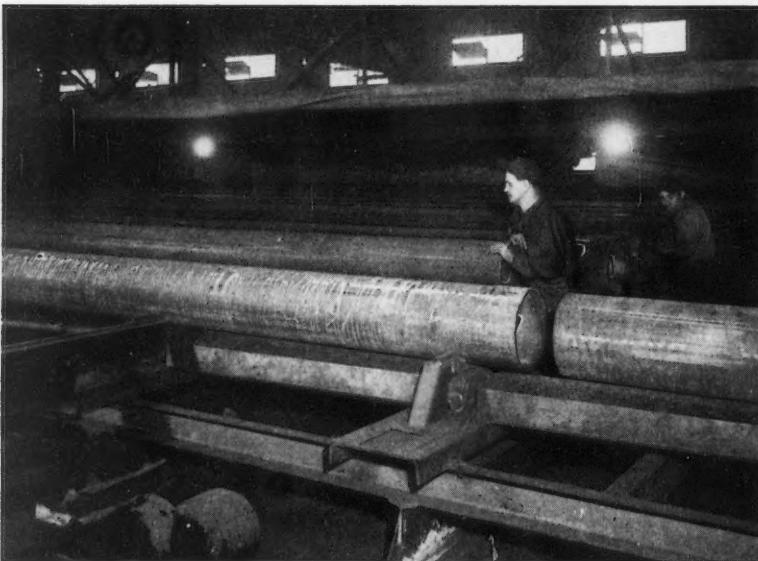
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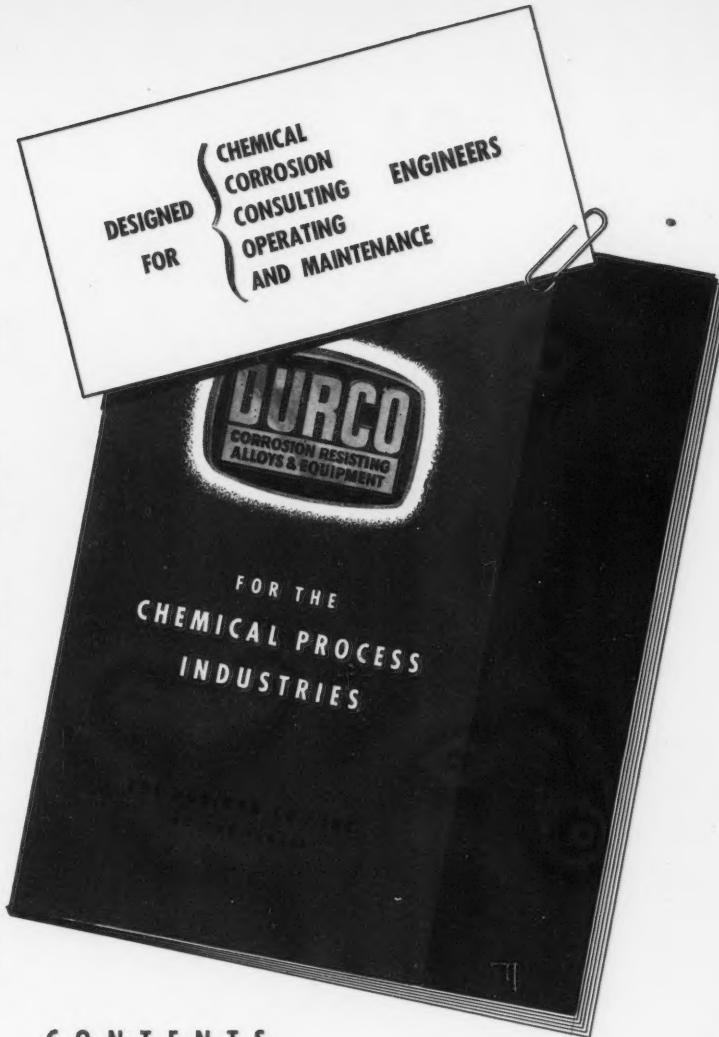
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